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ABSTRACT

The handbooks for the most widely used computer-assisted instruction (CAI) courses now available on computer terminals at the Institute for Mathematical Studies in the Social Sciences at Stanford University are presented. Handbooks are included for the following courses: Strands Drill-and-practice (arithmetic fundamentals for fourth grade), Logic and Algebra (for secondary or gifted elementary students), BASIC programing (for high school students), AID programing (for junior college students with a year of algebra), and CAI Basic English (for twelfth grade or beginning community-college students). The purposes and procedures for each course are described, along with examples or summaries of programs used. A proctor's handbook, which provides step-by-step instructions on the use of student programs and teacher's reports, along with information on guest demonstrations is included. A maintenance handbook describes the various elements in the communications network and some simple repairs that a teacher or proctor may do. A bibliography of the Institute's research publications is given. (JK)

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TEACHER'S HANDBOOK FOR CAI COURSES

BY

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TEACHER'S HANDBOOK FOR CAI COURSES

by

Patrick Suppes, Adele Goldberg, Grace Kanz,
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TECHNICAL REPORT NO. 178

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Institute for Mathematical Studies in the Social Sciences
Stanford University
Stanford, California

PREFACE

This Handbook describes the most widely used computer-assisted instruction courses now available on computer terminals at the Institute for Mathematical Studies in the Social Sciences.

A number of other courses of a more special nature, still in the process of rapid development and change, are not described. These omissions include: Primary-grade Reading, Language Arts for Deaf Students, Elementary Russian (two-year college course), and Introduction to Elementary Mathematical Theories (college level).

A bibliography of the Institute's research publications on computer-assisted instruction and related matters is included at the end of this Handbook.

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Patrick Suppes
Director, IMSSS

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Handbook for Computer-assisted Instruction in Programming: BASIC

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THE STRANDS DRILL-AND-PRACTICE HANDBOOK

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THE STRANDS DRILL-AND-PRACTICE HANDBOOK*

Individualized instruction has been a prominent theme in American education for over fifty years. Psychologists have shown that individuals differ in their abilities, their rates of learning, and often even in their general approaches to learning. Unfortunately the cost of providing individualized instruction that adapts to these differences is prohibitive if it depends on the use of professional teachers. Faced with these obstacles, most schools at best implement some innovative technique, such as team teaching, which usually reduces only temporarily group sizes for certain subjects.

Many modern mathematics programs have produced texts that emphasize structure and understanding, assuming that the teacher independently provides needed lessons on fundamental skills. In practice, however, many teachers fail to provide the needed drill on fundamentals, thinking that "modern math" programs somehow eliminate the need for the more traditional daily reviews on fundamental skills. The result is that students in many modern programs fail to score as well as expected in skill areas.

The mathematics drill-and-practice program is the sixth edition of work that began during the 1964-65 school year. Each edition has been a revision and expansion of previous editions based on accrued experience and performance data. Beginning with a single class of 41 fourth-grade students in 1965, the program has expanded each year until nearly three-quarters of a million lessons were taken by nearly 8,500 students during the 1969-70 school year.

The effort required to provide a well-planned program of review and practice lessons in arithmetic fundamentals in a computer-assisted instructional environment is considerable. For example, in the third edition of this program, an average of 16 hours of writing, coding, editing, and checking was required for each 10-minute segment of the program.

The strands drill-and-practice program became operational in April 1970. The objectives of this program are (a) to provide daily,

*This program was developed under National Science Foundation Grant NSFG 1-8709.

supplementary individualized instruction in elementary mathematics at a level of difficulty appropriate to each student's level of achievement; (b) to allow acceleration in any concept area in which a student demonstrates proficiency; and (c) to provide each teacher with a daily profile report of each student's position in the concept areas.

1. The Strands Approach

A strand is a series of problems of the same operational type (e.g., counting and place value, addition, subtraction, fractions) arranged sequentially in equivalence classes according to their relative difficulty and is available for Grades 1 through 7.9. Table 1 shows the 14 strands in the program and identifies each strand by a three-letter abbreviation that designates the first and last class of problems in each strand. Each student in the strands program will work on fewer than 14 strands; the actual number will depend on his grade level and performance. The strands approach provides perhaps the highest degree of individualization to date, because (a) each student's lesson is prepared for him daily by the computer; (b) the lessons are presented as mixed drills at a level of difficulty in each concept determined by the student's prior performance in each concept; and (c) the student moves up each strand at his own pace.

2. Initial Placement on the System

Students are placed on the system, using their current grade in school as a guide. As a result, students may be presented with exercises that are either much too easy, or much too hard. For the first ten sessions, the computer is programmed to move students as much as half a grade level at a time to allow each student to reach his appropriate level rapidly. These discrepancies should prevail for only a few sessions. In addition to providing for large changes in grade level during the initial sessions, the computer is also programmed to move each student up and down each strand, depending on his performance. Correct responses move students up, incorrect responses move students down.

TABLE 1

Mathematics Strands

Strand Number	Abbreviation	Name	Grade-level First Class	Grade-level Last Class
1	NUM	Number concepts	1.0	7.9
2	HAD	Horizontal addition	1.0	3.9
3	HSU	Horizontal subtraction	1.0	3.4
4	VAD	Vertical addition	1.0	5.9
5	VSU	Vertical subtraction	1.5	5.9
6	EQN	Equations	1.5	7.9
7	MEA	Measurement	1.5	7.9
8	HMU	Horizontal multiplication	2.5	5.4
9	LAW	Laws of arithmetic	3.0	7.9
10	VMU	Vertical multiplication	3.5	7.9
11	DIV	Division	3.5	7.9
12	FRA	Fractions	3.5	7.9
13	DEC	Decimals	4.0	7.9
14	NEG	Negative numbers	6.0	7.9

3. Individual Lessons and Student Responses

The problems presented to a student during a single session are selected from all the strands the student is working on and are given in a mixed order. Thus, each session is a "mixed drill." This type of problem presentation may cause difficulties for students, especially at the start of the program, since they must categorize a problem before solving it. The problems for each student are selected according to an objective distribution.

Time Limit. A student is allowed 20 seconds for each response. If he does not respond within 20 seconds, the message TIME IS UP, TRY AGAIN is typed. The problem is retyped to the point where the time out occurred, and if the student does not respond within another 20 seconds, the message TIME IS UP, THE ANSWER IS _____, TRY AGAIN is typed. The problem is typed a third time to the same point. If the student again does not type an answer in 20 seconds the problem is retyped with the correct answer. The next problem then follows.

Wrong Answers. When a student types a wrong answer the message NO, TRY AGAIN is typed. The problem is retyped to the point where the error occurred. If a wrong answer is typed again, the message NO, THE ANSWER IS _____, TRY AGAIN is typed. The problem is retyped a third time. A third error causes the error message to be repeated and the answer to be given. The problem is typed again with the correct answer. The next problem then follows.

4. Grade-level Numbers

The assignment of grade-level numbers to problem types presented many difficulties and is potentially the most controversial aspect of the program for teachers and administrators. The grade-level numbers assigned have two functions: they serve as labels for problem types, and they describe the order in which problem types are placed in the curriculum. If the grade-level number of a problem, say 4.3, were accurate, we would expect the average student who was three-tenths of the way through the fourth grade to be able to do the problem. However, data relating performance to grade placement are scarce, and only after

further experience with the strands program will it be possible to assign grade-level numbers that represent performance of students.

The assignment of grade-level numbers was based on an examination of several arithmetic text series, an analysis of data from the block drill-and-practice program, and the experience of the staff. First, problems from texts were assigned numbers corresponding to the year and to the portion of the text in which they first appeared. Then, using performance data from the block program, we changed many of the original numbers. Further adjustments were made on the basis of advice from teachers and the accumulated experience of the staff. Problems in four of the strands were given numbers starting with 1.0, although children do not start work on such problems until sometime later in the year.

For the present, the staff encourages teachers to consider the numbers as relative placement of students. That is, a student whose grade placement on a strand is 4.5 is solving more difficult problems than the student whose placement is 4.0.

5. Average Grade Placement

The position of each student on the strands is characterized by a number called the average grade placement. This number is not the simple average of position on all strands, but is calculated to give more weight to strands that form a larger part of the curriculum. Thus, a low (or high) grade level on a strand that forms only a small part of the curriculum will not change a student's average grade placement much, whereas a low (or high) placement on a strand that forms a major portion of the curriculum will affect the average grade placement considerably.

6. Standardized Change in Average Grade Placement

Movement on the strands can be measured in different ways. One way is to subtract a student's average grade placement at the beginning of a time period from his placement at the end of the time period. This is a common measure of performance, but the number obtained does not reflect the difference between the student who works every day, slowly, and the student who works faster, but who has been absent for some sessions.

The staff chose to measure the rate of progress of individual students by using a number called the standardized change in average

grade placement. This number allows comparison of the progress rate of students, even if they have taken different numbers of lessons during the time period. The number is calculated every two weeks and is available on the daily teacher's report. To illustrate the use of the standardized change in average grade placement, consider a specific example. Suppose John and Betty change their grade placement one-hundredth of a year (.01) each time they take a lesson. During a two-week period, John takes 10 lessons, Betty takes 5. Looking at absolute numbers, John will have progressed .10 of a year, Betty .05 of a year. However, the standardized change for both of them, which reflects the fact that their rate of progress is the same, will be .12 of a year.

The student who works at the teletype every day at a rate that will enable him to complete one year of strands curriculum in one school year may be expected to achieve a standardized change in average grade placement of .10. A student whose standardized change is greater than .10 will complete a year's curriculum in less than a school year if he works every day. If the number representing the standardized change is negative, the student's position at the end of the two-week period will be lower than it was at the beginning of the period.

7. Number of Lessons

In the strands program, the unit for measuring a lesson is time. Each lesson runs a specified number of minutes; therefore, there is a wide spread in the number of problems that each student does during a lesson. The length of a lesson depends on the student's grade in school and varies from 5 minutes for first graders to 10 minutes for sixth graders. If for any reason a student terminates work at the teletype before his time is up, the minutes remaining in the lesson are presented at the next sign on. The number of lessons a student has taken (shown in the teacher's report) does not necessarily equal the number of sign ons.

8. Daily Report

A daily report of the student's progress in the strands program is available every day at the teacher's request. A sample printout is shown on page 8. (Refer to "Proctor's Handbook" on page 13 for method of requesting daily report.)

As can be seen in the printout in Figure 1, the report for each student occupies two lines. The first line shows AVG, the average grade placement; CHG, the standardized change in average grade placement reported to two decimal places; SES, the number of completed sessions from the student's first sign on through the day of the report, (:) after the session number indicates that the student did not complete the lesson and still has time left in that session; PBS, the total number of problems the student has completed from his first sign on through the date of the report; (+), a space for a plus sign is printed if the student signed on on the day of the report; and the name of the student. The following notations in place of a decimal number may appear in the CHG column. An NA indicates that the student did not complete the first ten lessons at the start of the two-week period. An X indicates that the student did not complete any lessons during the two-week period, and thus, it was not possible to calculate a standardized change for him. A Y indicates to the Institute staff that the change reported for the student is based on more than two-and-a-half weeks, because the student had not signed on the system for several days before the start of the two-week period. A WW indicates an error in the student's record on that item for that day.

The second line of the report contains the grade placement of each student on each strand. If the student has not begun a strand, the grade-placement position for that strand is left blank. If the student has completed a strand, the highest grade placement for that strand is reported with a T after it, until the entire class has completed the strand. Therefore, the grade-placement position for the student, as well as the average grade placement for the class on that strand, is left blank.

Summary class data for each statistic reported for individual students are shown at the bottom of the daily report. Each class mean is the average of the numbers shown in the body of the report. Grade placements followed by T are not included in class mean. Each number printed under HIGHEST (or LOWEST) is the highest (or lowest) score attained by a student in the class.

```
CLASS 230     TEACHER'S NAME     DATE
7 STUDENTS     SCHOOL NAME     GRADE 2

MATH STRANDS REPORT

AVG   CHG   SES   PBS
                  NUM  HAD  HSU  VAD  VSU  EQN  MEA  HMU  LAW  VMU  DIV  FRA  DEC  NEG

20     WW    12:  302   +   220   STUDENT NAME
                  20   20   20   20   20   20   20

60     NA    18   273   +   780   STUDENT NAME
                  59                     60   60        60   60   60T  69   60   60

17      Y    21   503       289   STUDENT NAME
                  17   16   17   16   17   15   16

29     NA    95:  3525  +   403   STUDENT NAME
                  30   30   30   30   29   30   30   30   30

16     NA     1   125       340   STUDENT NAME
                  16   16   16   16   15   17   16

10     NA     1:  3     +   230   STUDENT NAME
                  10   10   10   10

46      X    16   338   +   682   STUDENT NAME
                  46                49   48   46   45   47   45   46   45T  47   45


CLASS MEANS
27           23   722
                  28   18   18   23   32   39   38   38   45   53        53   52   60

HIGHEST
60           95   352
                  59   30   30   49   48   60   60   47   60   60   45T  59   60   60

LOWEST
10           1    3
                  10   10   10   10   20   20   20   30   30   46        47   45   60
```

Fig. 1. Sample printout, Math Strands Report.

9. Grade Placement of Topics in the Strands

The following pages summarize the contents of the 14 strands. Sample types of problems for each half-grade level are given. This helps the teacher to identify the types of problems each student will do during his daily drill on the teletype.

1. Summary of the Content of the Number Concepts Strand

Half-grade Level	Problem Types	Sample Problems
1.0	Count arrays of letters. Count to 10. (The student is asked to supply a missing digit in a series, as shown at right.)	How many? How many T's? B B B X T T X T __ __ Count 2 _ 4 5
1.5	Count to 50. Place-value problems, tens and ones. Count backwards from 9.	30 = _ tens
2.0	Count to 200. Count by 10 to 50. Place value, tens and ones. Count backwards from 20.	75 = _ tens and _ ones Count 7 _ 5 4
2.5	Count by 2 to 20. Place value, tens and ones.	Count by 2's 12 14 _ 18
3.0	Place value, hundreds, tens and ones. Count by 2, starting with odd number. Count by 5 to 50.	Count by 2's 3 5 _ 9 11
3.5	Recognizing even and odd numbers. Count backwards by 2 from 20. Count by 2 to 100. Place value, thousands, hundreds tens, ones.	Which is even? 5, 2, 9 Type it _
4.0	Count by 3 to 30. Count by 5 to 150. Place value (see example). Count by 3, starting with a number not a multiple of 3.	What digit is in the tens place in 432? Type it _
4.5	Count by 3, by 4, by 6 and by 7. Recognize even and odd numbers.	Count by 6's 12 18 _ 30
5.0	Round to the nearest tens place. Average two numbers. Recognize primes below 40.	Type 374 rounded to the nearest tens place. __
5.5	Work with average of three numbers. Round to the nearest hundreds or thousands place. Recognize factors, multiples.	Which is a factor of 9? 2 3 18 24 Type it _

Number Concept Strand (continued)

Half-grade Level	Problem Types	Sample Problems
6.0	Recognize prime factors of a number. Find the greatest common denominator, least common multiple of a pair of numbers. Round decimals to the nearest whole number, tenth or hundredth. Count by tenths.	Type the least common multiple of 10 and 15 ___
6.5	Count by hundredths. Write numbers using exponents. Calculate using the laws of exponents.	$A^3 \times A^5 = A^D$ D= _ $8 = A^B$ A= _, B= _
7.0	Find averages to the nearest tenth. Work with decimals written in expanded notation. Find square roots. Find factors and multiples. Round decimals.	Type the decimal 5×10^{-4} = __ Round 2.326 to the nearest tenth
7.5	Compare numbers written in exponential form. In base two and base five, count, convert to base ten, add and subtract.	Type < or > 2^{-5} __ 2^{-4} 100 (base 2) = ___ (base 10)

2. Summary of the Content of the Horizontal Addition Strand

Half-grade Level	Problem Types*	Sample Problems
1.0	Sums to 10 in canonical and noncanonical format.	1+2=_, 2+_=2, 5+3=_, _+3=6, 5+5=_
1.5	Sums to 10 in noncanonical format. Sums to 10 with three 1-digit addends. Sums with 2-digit addends.	2+_=9, _+7=10, 2+3+2=_, 20+5=_, 30+40=_
2.0	Sums with two addends from 10 to 18 in canonical and noncanonical format. Sums from 10 to 19 with three addends. Problems with sum on both sides of equal sign.	6+7=_, 2+3+7=_, _+5=13, 8+_=16, 2+4=1+_
2.5	Sums with 2-digit addends in canonical format. Sums with regrouping in canonical format. Problems with sum on both sides of equal sign.	12+3=_, 7+5=10+_, 26+2=_, 36+7=_, 5+58=_
3.0	Sums with 2-digit addends, with and without regrouping. Problems with sum on both sides of equal sign. Sums with three addends.	60+90=_, 21+32=_, 8+7+9=_, 7+4=_+8, 16+25=_
3.5	Sums in noncanonical format, with and without regrouping.	6+_=28, _+14=18, 26+38=_, 35+_=44, _+28=33

*The problems 5+2=_ and 3+2+1=_ are in canonical format; the student is asked to enter the sum. The problems 2+_=9, _+5=6, and 2+0=_+1 are in noncanonical format; the student is asked to enter a missing addend.

3. Summary of the Content of the Horizontal Subtraction Strand

Half-grade level	Problem Types*	Sample Problems
1.0	Differences in canonical and noncanonical format. Maximum minuend is 9.	4-0=_, 8-4=_, 2-_= 1, 6-2=_, 7-_=7
1.5	Differences in canonical and noncanonical format. Maximum minuend is 10.	8-3=_, _-2=1, 10-4=_, 9-_=6, _-0=6
2.0	Problems with two-digit minuends in canonical format. Problems with one-digit minuends in noncanonical format.	13-10=_, _-4=5, 12-8=_, 16-6=_, 30-20=_
2.5	Problems with two-digit minuends ≤ 19 in noncanonical format. Problems with minuends > 19 in noncanonical format. Problems with a difference on both sides of equal sign.	16-_=8, 6-0=7-_, 17-12=_, _-6=7, 26-22=_, 35-4=_
3.0	Problems with a regroup, in canonical format. Problems without a regroup, in noncanonical format. Problems with a difference on both sides of equal sign.	35-22=_, 4-2=8-_, 74-_=70, 43-8=_, 56-_=2

*The problem 4-0=_ is in canonical format; the student is asked to enter the difference.
The problem 7-_=7 is in noncanonical format; the student is asked to enter a missing addend.

4. Summary of Content of the Vertical Addition Strand

Half-grade Level	Sample Problems				
1.0	3 +2	1 +0	3 1 +2	5 +4	
1.5	10 + 6	20 +60	30 + 6	10 20 +40	3 1 1 +2
2.0	5 +5	7 +6	10 10 + 2	40 +70	10 10 3 +10
2.5	42 + 6	7 +51	20 30 + 5	21 +63	23 + 8
3.0	30 10 +40	217 + 32	51 +73	6 2 1 +8	285 +172
3.5	22 41 +36	349 + 37	5 7 +19	3363 +1433	72 81 +73
4.0	8 2 6 +8	25 23 +15	6824 +1945	193 +668	996 +564
4.5	6847 +5273	21 40 72 +83			

Vertical Addition Strand (continued)

Half-grade Level	Sample Problems	
5.0	625 214 +345	1376 +5848
5.5	272 49 923 + 21	4362 7188 +6725

There are only a small number of problems in classes from level 4.5 to 5.9. The first problems with regrouping are found at level 2.8.

5. Summary of the Content of the Vertical Subtraction Strand

Half-grade Level	Sample Problems				
1.5	4 -2	5 -0	7 -3	8 -6	30 -10
2.0	10 - 4	13 - 8	16 -10	17 - 9	35 - 5
2.5	17 - 6	150 - 70	28 -26	78 -28	47 -32
3.0	36 -28	137 -125	128 - 42	172 - 37	480 - 35
3.5	236 - 72	553 -528	427 -382	767 -483	987 -248
4.0	3958 -2103	124 - 87	426 -378	700 -435	7372 - 148
4.5	8364 - 282	1205 - 728			
5.0	4286 -1497	9022 -4678			
5.5	9000 -6741	33215 -18438			

There are only a small number of problems in the classes from level 4.5 to 5.9. The first problems with regrouping are found at level 3.0.

6. Summary of the Content of the Equations Strand

Half-grade Level	Problem Types*	Sample Problems
1.5	Equations of sums and differences to 10, horizontal format	2+5=D, D=_ 10-T=4, T=_
2.0	Inequalities, numbers to 100. Equations of sums and differences to 18, horizontal format.	Type < or > 14 _ 16
2.5	Inequalities, involving sums and differences. Equations of sums and differences in horizontal and vertical format.	Type < or > 4+2 _ 7 3 +2 F, F=_
3.0	Inequalities involving sums and differences. Equations with sums or differences on both sides of the equal sign. Sums and differences in vertical format with letter variable in body of problem. Equations with sum or difference on left.	Type < or > 4-1 _ 6-2 3+2=A+1 A=_ B +3 7, B=_ 4=17-D D=_
3.5	Comparisons where no calculations needed. "Find the missing digit" problems. Inequalities and equations, in horizontal format, involving multiplication.	Type < or > 25+72 _ 25+30 Find the missing digit 23 +G2 65, G=_
4.0	"Find the missing digit" problems. Inequalities, and equations in horizontal and vertical format, involving multiplication and division.	25=5xP, P=_ 4=B/3, B=_
4.5	Inequalities and equations involving division and simple fractions. Equations involving the quantity (axb)+c (which is part of the multiplication algorithm).	1/2 of B = 6, B=_ (2x4)+2=K, K=_
5.0	"Find the missing digit" problems. Equations involving division and operations on fractions.	3F4 -126 228, F=_

Equations Strand (continued)

Half-grade Level	Problem Types	Sample Problems
5.5	"Find the missing digit" problems. Equations involving division with remainder. Equations involving fractions.	27/4 = 6+R/4, R=_ 1/2+F/4 = 5/4, F=_
6.0	Equations with two variables, and information supplied. Equations and inequalities involving decimals, fractions.	A+K = 14 A=6, so K=_
6.5	Equations with two variables. Equations and inequalities involving decimals and fractions.	T/4 divided by 6/7 = 14/24 T=_
7.0	Equations reviewing fundamental operations. Identifying correct placement of decimal point in solution of decimal equations. Solution of equations involving negative numbers.	Choose the correct solution Y x .27 = 3.24 A. Y = 1.2 B. Y = .12 C. Y = 12.0 D. Y = 120
7.5	Identification of pairs of numbers which will satisfy an equation. Solution of open statements involving inequalities. Equations using numerals written in base 2 or base 5.	If k < 7, which is true A. 8-k >1 B. 5+k >12 C. 4 <k-3

*There are several classes of comparison problems for which the instructions are "Type < or = or >." These will be referred to as inequalities although the quantities compared are in some cases equal.

7. Summary of the Content of the Measurement Strand

Half-grade Level	Problem Types*	Sample Problems
1.5	Recognition of words for numerals to 10. Money problems using pennies.	Type THREE _ 2 pennies + 3 pennies = _ pennies
2.0	Money problems using pennies, nickels, dimes. Conversions using liquid measure.	2 nickels = _ cents 1 quart = _ pints
2.5	Recognition of number names to 100. Conversion problems using liquid and linear measure. Inequalities.	1 foot = _ inches Type < or > 14 things _ 1 dozen
3.0	Recognition of number names to 200. Conversion and comparison using money, liquid and linear measure.	Type ONE HUNDRED NINETY TWO _____ 2 quarts = _ pints
3.5	Recognition of number names to 1000. Conversion and comparison using money, liquid and linear measure, and time.	31 ounces = _ pounds _ ounces
4.0	Recognition of number names to 5000. Sums and differences using liquid and linear measure, time.	15 seconds + _ seconds = 1 minute
4.5	Recognition of number names to 10,000. Roman numerals. Calculations using time, linear measure.	How many hours are there from 2 o'clock to 7 o'clock? __ 3 yds 2 ft + 5 yds 2 ft _ yds _ ft Now regroup the answer _ yds _ ft
5.0	Sums, differences, and products using weight, linear measure, time. Fractional parts of liquid measure, linear measure, and weight.	1/3 dozen = _ things 13 ft = _ yds _ ft
5.5	Recognition of number names to 100,000. All arithmetic operations, using time, weight, linear measure.	8 lbs 3 oz x 7 _ lbs _ oz Now regroup the answer _ lbs _ oz

Measurement Strand (continued)

Half-grade Level	Problem Types	Sample Problems
6.0	Metric measurement, conversion. Scientific notation. Recognition of number names to 1 million.	Scientific notation $325 = 3.25 \times 10^{A}$ A = __
6.5	Metric measurement. Scientific notation. Inequalities.	Type < or > 2.5×10^{2} __ 2.5×10^{3}
7.0	Inequalities requiring measure conversions. Multiplication using linear and weight measure	Type < or = or > 62 in. __ 2 yd.
7.5	Calculations using time. Word problems using area, perimeter, volume.	The time is now 5:15 P.M. What time was it 7 hr. 30 min. ago A. 9:45 A.M. B. 9:45 P.M. C. 12:45 P.M. D. 12:45 A.M.

*Units used in strand.
Liquid: cup, pint, quart, gallon.
Linear: inch, foot, yard.
Weight: ounce, pound, ton.
Time: second, minute, hour, day, week, year.
Metric: millimeter, centimeter, decimeter, meter, kilometer, gram, kilogram.
Square: inches, feet, yard, miles.
Cubic: inches, feet, yard.

8. Summary of the Content of the Horizontal Multiplication Strand

Half-grade Level	Problem Types	Sample Problems
2.5	Repeated addition and the associated products.	4+4+4=_ _ fours = 12 3 times 4 = _
3.0	Products with one factor 0 or 1. Products with factors ≤ 5, in canonical and noncanonical format.	8x0=_ 3x_=15
3.5	Products to 9x9, in canonical and noncanonical format. Products with one factor 10, 11, or 100.	8x9=_ _x4=36
4.0	Products with one factor 10, 11, or 12, in canonical and noncanonical format. Products with one factor a multiple of 10. Products with three factors, one of which is 1.	12x4=_ 2x1x5=_ 30x6=_
4.5	Products with one factor a multiple of 10 or 100, in canonical and noncanonical format. Products with three factors, one of which is 12.	_x6=120 3x2x4=_
5.0	Products with one 1-digit and one 2-digit factor.	14x3=_ 4x21=_

9. Summary of the Content of the Laws of Arithmetic Strand

Half-grade Level	Laws* and Problem Types	Sample Problems
3.0	*Addition is commutative. *Multiplication is commutative. *Zero is the identity for addition. *One is the identity for multiplication. Multiplication is associative.	3+5=5+_ 2x6=6x_ 30+_=30 _x16=16 2x(4x3)=(2x4)x_
3.5	*Addition is commutative. *Multiplication is commutative. *Multiplication is distributive. *Subtraction undoes addition. *Division undoes multiplication.	6x(7+2)=(6x_)+(6x2) 94+77=171, so 171-94=_ 73x45=3285, so 3285/73=_
4.0	*Subtraction is not commutative. *Multiplication is distributive. *Addition undoes subtraction. *Division is not commutative. *Multiplication undoes division.	Type = or ≠. 58-43 _ 43-58 6x(7-3)=(_x7)-(6x3) 57-39=18, so 18+39=_ Type = or ≠. 2/7 _ 7/21 1943/29=67, so 29x67=_
4.5	*Distributive law. *Subtraction is not associative. Multiple choice, using laws as reasons. *Multiplication is distributive.	5x18=5x(_+8) =(5x10)+(5x_) =50+_ =_ Type = or ≠. (6-4)-3 _ 6-(4-3) Give the reason 52+0=52 because A. Addition is commutative. B. Subtraction is not commutative. C. Zero is the identity for addition. D. Addition is associative. Type the letter _
5.0	*Division is not associative. Multiple-choice problems. *Properties of inverses. *Distributive law.	Type = or ≠. (43/23)/10 _ 45/(23/10) (25+14)-14=_

Laws of Arithmetic Strand (continued)

Half-grade Level	Laws* and Problem Types	Sample Problems
5.5	Multiple-choice problems. *Multiplication is distributive. *Division is distributive.	(35+62)/40=(35/40)+(_+40)
6.0	*Distributive law. Multiple choice. Counterexamples.	36-28 = 28-_
6.5	Multiple choice. *Laws illustrated using letter variables.	(m+n)+p= m+(_+p)
7.0	Application of basic laws to problems using decimals, negative numbers and fractions.	72/59x_/72 = 1 __+39 = 0
7.5	Multiple-choice questions calling for the identification of the correct rule.	(27/8)-(14/8) = (27-14)/8 because A. Division is distributive over addition. B. Division is distributive over subtraction. C. Division is not associative. D. Division is not commutative.

*Almost all the problems in the strand can be answered without performing any calculations; correct responses without calculation depend on the application of the basic laws of arithmetic.

10. Summary of the Content of the Vertical Multiplication Strand

Half-grade Level	Sample Problems				
3.5	2 x4	12 x 3	23 x 3	72 x 4	16 x 3
4.0	28 x 3	132 x 3	35 x 5	532 x 2	86 x 8
4.5	717 x 2	640 x 3	97 x50	147 x 6	849 x 3
5.0	925 x 7	60 x14	7216 x 3	93 x22	6225 x 7
5.5	432 x 50	43175 x 6	47 x23		
6.0	209 x 36	672 x400	67 x88		
6.5	1632 x 8	762 x408	937 x428		
7.0	92358 x 6	853 x 72			
7.5	692 x 58	749 x629			

There are only a small number of problems in classes from level 5.5 to 6.9.

11. Summary of the Content of the Division Strand

Half-grade Level	Problem Types *	Sample Problems
3.5	Problems using slash, one-digit division.	35/7=_ 6/6=_
4.0	Problems using slash, divisors to 12. Problems using long division estimation format, one-digit divisor, remainder zero.	121/11=_ $7\overline{)42}$
4.5	Problems using long division format, one-digit divisors, some r≠0. Problems using slash, with dividend or divisor multiple of 10 or 100.	$4\overline{)84}$ $4\overline{)27}$ $6\overline{)486}$ 2100/30=_
5.0	Problems using long division format, one-digit divisor or divisor a multiple of 10, dividend 2 or 3 digits.	$6\overline{)91}$ $7\overline{)805}$ $80\overline{)320}$
5.5	Problems using long division format, one-digit divisor or divisor a multiple of 10, 3 or 4-digit dividend.	$6\overline{)6236}$ $70\overline{)395}$
6.0	Problems using long division format, one-digit divisor, 5-digit dividend, 2-digit divisor, 3-digit dividend.	$6\overline{)62224}$ $25\overline{)154}$
6.5	Problems using long division format, 2- and 3-digit divisors.	$37\overline{)4624}$ $279\overline{)46752}$
7.0	Review of problems in slash format. Review of problems in long division format.	568/8= $42\overline{)327}$ —
7.5	Review of problems in long division format.	$54\overline{)9728}$ $148\overline{)8478}$

* There are two types of long division formats. In "estimation" format, the student is asked to enter only partial quotients, and perform the last subtraction operation. In the standard format the student must carry out all the operations necessary to solve the problem. Estimation format is used throughout the strand to introduce more difficult problem types.

12. Summary of the Content of the Fraction Strand

Half-grade Level	Problem Types	Sample Problems
3.5	Fractions used to describe subsets.	TTKKK How many letters _ _/5 of letters are T _/5 of letters are K 2/5 + 3/5 = _/5 = _
4.0	Fractions used to describe subsets.	A B C C A B C C A B C C How many letters _ _/4 of letters are A _/4 of letters are B _/4 of letters are C Type < or > 1/4 _ 2/4
4.5	Inequalities. Addition and subtraction of fractions with the same denominator. Writing equivalent fractions. Converting to a mixed number.	Type < or > 1/8 _ 1/9 1/4 = _/8 12/7 = 7/7 + _/7 = _ + 5/7 = _ 5/_
5.0	Addition and subtraction of fractions with the same denominator. Addition of mixed numbers. Multiplication of a fraction by a whole number.	5 x 1/8 = _/_ 6 3/10 + 5/10 = 6 + (_/10+5/10) = 6 _/10 = 6 _/5
5.5	Addition and subtraction of mixed numbers, same denominators. Addition and subtraction, one denominator a multiple of the other. Multiplication of fractions.	3/5+3/20 = _/20 + 3/20 = _/20 = _/4 How many 1/8 in 2? _ 1/4 x 1/5 = _/_
6.0	Inequalities. Addition, subtraction, multiplication. Whole number divided by a fraction.	Type < or = or > 2/3 _ 5/7 7 divided by 1/5 = 7 x _/1 = _
6.5	Percents, simple conversion. All operations.	3/4 = _/100 = _ percent 6/8 divided by 1/3 = 6/8 x _/_ = _/_
7.0	Problems in non-canonical format.	9/__ X 9/6 = 81/60 4/6 divided by __/7 = 28/30
7.5	Percents, identification of equivalent fractions.	Which fraction is equivalent to 225 percent? A. 5/2 B. 9/4 C. 10/5

13. Summary of the Content of the Decimal Strand

Half-grade Level	Problem Types	Sample Problems
4.0	Addition and subtraction of decimal numbers written as dollars and cents.	$2.43 + 6.24 ; $.46 - .32
4.5	Addition and subtraction of decimal numbers written as dollars and cents.	$6.00 - 2.38 ; $4.63 + 2.58
5.0	Addition, subtraction, and multiplication with decimal numbers written as dollars and cents.	$4.21 x 7
5.5	Addition, subtraction, multiplication of decimal numbers. Equivalent fractions and decimals.	.6 x .7 = _ Type equivalent fraction .23 = _/100
6.0	Calculations with decimals. Comparing fractions and decimals.	12/4=_ .27 minus one-tenth=_ Type < or = or >. 4/5 _ .7
6.5	Multiple choice: correct placement of decimal point. Decimal equivalent of mixed numbers. Inequalities.	735x.27= A) 19.845 B) 1.9845 C) 198.45 D) 1984.5 Type the letter _ Type the equivalent decimal 3 3/5 = _ Type < or = or > 24x3.2 _ 240x.032 How many .4 in 2?
7.0	Inequalities, computations.	Type < or = or > .023 __ .02 .23 times one tenth= __
7.5	Computations, percents.	.12 x 56 = 6.72, therefore __ percent of 56 is 6.72 .035/.5 = __

14. Summary of the Content of the Negative Number Strand

Half-grade Level	Problem Types	Sample Problems
6.0	Inequalities. Counting. Addition and subtraction.	Type < or > -7 __ -6 Count -16 __ -14, -13
6.5	Subtraction, multiplication, and division.	5-(-6)= __ (-9)x(-7)= __ 14/2= __
7.0	Inequalities, calculations.	Type < or > -33 __ -57 -.8 __ -.1 -615 minus one hundred = ___
7.5	Inequalities, problems in non-canonical format.	Type = or ≠ 9-(-6) __ 15 Type < or > 3/4 __ -3/4 __-(-1)= -8

LOGIC AND ALGEBRA HANDBOOK

LOGIC AND ALGEBRA HANDBOOK*

Logic is an essential tool to clear thinking. It is also the foundation of mathematics and is a desirable part of the curriculum, even at the elementary-school level. It has no specific prerequisites; thus, the formal study of logic may be introduced at any time. Once it is available, however, other subjects can be approached in new and significant ways.

Research at IMSSS has shown that youngsters, even at second- and third-grade levels are capable of significant achievement in formal logic (Suppes & Hansen, 1965; Suppes, 1966; Suppes & Ihrke, 1967). The present program is written to present lessons in logic which the students can learn at the teletype without depending on a logic teacher. Students should be encouraged to work on their own, and help should be offered only when the student cannot proceed. We have found that when help is offered too freely, the children use it more than needed; the students usually are able to proceed without assistance when they are required to. The supervising teachers should keep ahead of the students in progressing through the lessons.

The two years of curriculum described here is meant for secondary school students. It has also been used fairly extensively with gifted elementary-school students.

Students should be told that the multiple-choice problems in the introductory parts of the program contain important information. Also, the more difficult derivations are often preceded by easier ones that show what the first steps can be. Students should be reminded to look at previous problems as they progress.

There are often many ways of deriving a given conclusion from given premises. In general, the rules simply show what can be done. Which rules to use and the details of their use are matters of strategy determined by experience and ingenuity. The computer will allow any valid step, whether or not it helps reach the conclusion.

If deriving conclusions proves difficult, the strategy questions in Table 1 may be of help.

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TABLE 1

Strategy Questions

I. General questions

1. Does any given premise, or its denial, appear within any other premise?
2. If so, is there any rule that lets you use them together?

II. Pick out a premise you think you might be able to use, then ask yourself these questions:

1. What kind of formula is it?
2. Which rules may apply to that kind? For each rule, ask the next question.
3. Exactly which additional formula would you need to apply the rule? Do you have it or see any way to get it?

Example: IF NOT R THEN S The answers to the questions are:

a. It is a conditional.
b. Rule AA.
c. NOT R.

III. The conclusion:

Can you find the conclusion within any premise? How could you get it out?

The first year of the logic-algebra program is basically a tutorial course in elementary logic which is concerned with introducing numerical and sentential variables, forming algebraic terms and sentences, and truth conditions of simple sentences. The logical connectives are introduced as well as their truth analysis. Along with the introduction of each connective, the rules of derivation appropriate to it are also presented. The student is required to make logical derivations using each of the rules, as well as more complex derivations combining the rules. In addition to the rules of logic, the student will also learn and use some algebraic rules. Several lessons are devoted to the concepts of validity of rules and validity of arguments.

The second year of the program is concerned with modern algebra. From a small set of axioms and rules of inference the properties of the field of rational numbers are developed. Beginning with the axioms for addition, the student proves some elementary theorems such as the cancellation law for addition. Thereafter, axioms for multiplication and ordering are introduced, and the student eventually derives as theorems the standard properties of the field.

An outline of the first and second years of the logic-algebra program follows the section on Procedures at the Teletype. Each outline is succeeded by an alphabetical list of the rules and axioms that are taught that year. The Logic and Algebra Handbook terminates with short explanations on how to use each rule and how to handle counterexample-mode problems.

Procedures at the Teletype

The computer consults the student's file and usually begins with the problem following the last one completed. An exception occurs if the student is within a loop block of problems. If so, he is returned to the beginning problem of the block, so that he can have the first problem of the block before him when answering the later problems.

The problems are listed by lesson with the problem number following a period. The lesson numbers are in octal, base eight, so the last problem of Lesson 107 is followed by 110.1. All problems are numbered by decimal numbers. Problem 101.7 is followed by 101.8.

On several of the derivations, the student is invited to ask for help after a certain time lapse by the message TYPE HINT AND THE ENTER KEY IF YOU WANT A HINT. The student should realize that he should not ask for help if he can manage without it. He may ask for it later if he has something he would like to try first. No hints are available on multiple-choice problems. The student may continue to respond to the choices until he finds the correct one. He should make an effort to remember then what the correct choice was.

The computer does four things while the student is trying to obtain the conclusion to be derived.

1. It examines each instruction by the student to see if it is in correct form and if it is an acceptable step. If it is not, an error message is printed.
2. It performs whatever acceptable step the student commands whether or not the step contributes to obtaining what is to be derived.
3. It compares each formula obtained with the desired conclusion. If the formula and conclusion are identical, the problem is terminated.
4. It may offer a hint on certain problems. This occurs after a fixed-time lapse. The hints programmed usually are starting hints. If the student has already completed steps, the hint may no longer be appropriate.

FIRST-YEAR LOGIC-ALGEBRA LESSONS

Lesson Number (octal)	Number of Problems (decimal)	Topic
101	19	Introduction to teletype
102	19	Number sentences Numerical variables
103	14	Sentential variables
104	39	Recognition of true and false sentences Assigning values to numerical variables
105	28	LT. Rule of Logical Truth
106	45	Negation and Denial
107	40	DN. Rule of Double Negation
110	14	Validity of Rules
111	27	FC. Form a Conjunction
112	31	Truth functional properties of conjunction
113	31	Atomic and molecular sentences Introduction to dominance
114	42	AA. Affirm the Antecedent
115	31	Truth functional properties of conditionals: false conditionals
116	24	Truth functional properties of conditionals: true conditionals
117	1	LC. Derive Left Conjunct RC. Derive Right Conjunct
120	33	Equations and inequalities Review of variables, molecular and atomic sentences
121	30	ND. Number Definition
122	29	CE. Commute Equals
123	29	AE. Add Equals

Lesson Number (octal)	Number of Problems (decimal)	Topic
124	29	RQ. Replace Equals
125	30	Disjunctions and Dominance
126	42	FD. Form a Disjunction
127	9	Truth functional properties of disjunctions: true disjunctions

FIRST-YEAR LOGIC-ALGEBRA RULES

(In Alphabetical Order)

Corresponding Logic Rule Names on Teletype (TTY)
and in Suppes & Hill Text (1964)

TTY		Text	
AA	(Affirm the Antecedent)	PP	(modus ponendo ponens)
AE	(Add Equals)		
CE	(Commute Equals)		
DC	(Deny the Consequent)	TT	(modus tollendo tollens)
DD	(Deny a Disjunct)	TP	(modus tollendo ponens)
DN	(Double Negation)	DN	(Double Negation)
FC	(Form a Conjunction)	A	(Adjunction)
FD	(Form a Disjunction)	LA	(Law of Addition)
LC	(Left Conjunct)	S	(Simplification)
LT	(Logical Truth)		
ND	(Number Definition)		(Definition)
RC	(Right Conjunct)		
RQ	(Replace Equals)		

SECOND-YEAR LOGIC-ALGEBRA LESSONS

Lesson Number (octal)	Number of Problems (decimal)	Topic
201	20	Recognition of true and false sentences; types of sentences; equations; inequalities.
202	40	Review of atomic and molecular sentences; conditionals; semantics for conditionals.
203	28	Review of AA. Affirm the antecedent. Truth value of conditionals as related to truth values of antecedent and consequent.
204	23	Review of ND. Number definition. Introduction to conditional proofs.
205	48	WP-CP. Working premise and conditional proof.
206	36	Use of WP-CP. DLL. Delete last line.
207	23	Valid rules of inference.
210	15	CE. Commute equals.
211	21	AE. Add equals.
212	28	SE. Subtract equals.
213	41	LT. Rule of logical truth.
214	50	Review problems. RE. Replace equals.
215	21	More about RE.
216	36	CA. Commute addition axiom. $(A + B) = (B + A)$. Short form of CA.
217	55	AS. Associate addition axiom. $(A + B) + C = A + (B + C)$. AR. Associate addition right. AL. Associate addition left.
220	18	Z. Zero axiom. $A + 0 = A$.
221	15	N. Negative number axiom. $A + (-B) = A - B$.
222	29	AI. Additive inverse axiom. $A + (-A) = 0$.

Lesson Number (octal)	Number of Problems (decimal)	Topic
223	106	Use of theorems in proofs. Theorem 1. $0 + A = A$. Theorem 2. $(-A) + A = 0$. Theorem 3. $A - A = 0$. Theorem 4. $0 - A = -A$. Theorem 5. $0 = -0$. Theorem 6. $A - 0 = A$. Story about algebraic tables and bears. Redundancy of AE, SE, CA, AR, AL.
224	44	Story about the relation of subtraction to addition. Theorem 7. $A + B = A + C \rightarrow B = C$. Theorem 8. $A + B = C \rightarrow A = C - B$. Theorem 9. $A = C - B \rightarrow A + B = C$.
225	20	Theorem 10. $A + B = 0 \rightarrow A = -B$. Theorem 11. $A = -B \rightarrow A + B = 0$. Theorem 12. $A + B = A \rightarrow B = 0$.
226	39	Theorem 13. $-(-A) = A$. Theorem 14. $(-(A + B)) + B = -A$. Theorem 15. $-(A + B) = (-A) - B$. Theorem 16. $(-A) - B = (-B) - A$. Theorem 17. $-(A - B) = B - A$.
227	37	Theorem 18. $(A - B) - C = A + ((-B) - C)$. Theorem 19. $(A - B) - C = A - (B + C)$. Theorem 20. $A + (B - A) = B$. Theorem 21. $A - (B + A) = -B$. Theorem 22. $(A - B) + (B - C) = A - C$.
230	24	CM. Commute multiplication axiom. $A \times B = B \times A$. Story about multiplication tables and bears. Division symbol /.
231	31	MU. Multiplication by unity axiom. $A \times 1 = A$. Continuation of story begun in 230. Theorem 30. $1 \times A = A$.
232	26	ME. Multiply equals. DE. Divide equals.

Lesson Number (octal)	Number of Problems (decimal)	
233	32	MI. Multiplicative inverse axiom. $A \times (1/A) = 1$, for $A \neq 0$. Discussion of the case where $A = 0$. Theorem 31. $(1/A) \times A = 1$, for $A \neq 0$.
234	63	U. Unity axiom. $1 \neq 0$. IP. Indirect proof.
235	58	Contraposition. Continuation of story begun in 224. FR. $A/B = A \times (1/B)$, for $B \neq 0$. Theorem 32. $1/1 = 1$. Theorem 33. $A/1 = A$. Theorem 34. $A/A = 1$, for $A \neq 0$.
236	18	Use of parentheses with connectives. Review of: LC, left conjunct; RC, right conjunct; FC, form a conjunct.
237	35	MS. Associate multiplication. $(A \times B) \times C = A \times (B \times C)$. MR. Associate multiplication right. ML. Associate multiplication left. Theorem 35. If $A/B = C$, then $A = C \times B$, for $B \neq 0$.
240	39	DL. Distributive axiom. $A \times (B + C) = (A \times B) + (A \times C)$. Theorem 36. $(B + C) \times A = (B \times A) + (C \times A)$. More about fractions. Theorem 37. $A \times 0 = 0$. Theorem 38. Not $1/A = 0$, for $A \neq 0$.
241	18	Story about king and wise men. Theorem 39. $0/A = 0$, for $A \neq 0$. Theorem 40. $A \times B = 1 \rightarrow B = 1/A$, for $A \neq 0$. Theorem 41. If not $A = 0$ & $A \times B = A$, then $B = 1$.
242	26	Computation of truth values of simple sentential expressions.
243	14	Validity; simple counterexamples.
244	22	Counterexamples.

AXIOMS AND RULES FOR SECOND-YEAR LOGIC-ALGEBRA

(In Alphabetical Order)

Rules

AL (Associate Addition Left)

AR (Associate Addition Right)

CM (Commute Multiplication)

DE (Divide Equals)

ME (Multiply Equals)

ML (Associate Multiplication Left)

MR (Associate Multiplication Right)

RE (Replace Equals)

SE (Subtract Equals)

WP-CP (Working Premise--Conditional Proof)

WP-IP (Working Premise--Indirect Proof)

Axioms

AI (Additive Inverse Axiom)

AS (Associate Addition)

CA (Commute Addition)

DL (Distributive Axiom)

FR (Fraction Axiom)

MI (Multiplicative Inverse Axiom)

MS (Associate Multiplication)

MU (Multiplication by Unity Axiom)

N (Negative Number Axiom)

U (Unity Axiom)

Z (Zero Axiom)

HOW TO USE THE AXIOMS AND RULES

(In Alphabetical Order)

1. AA - Affirm the Antecedent

P	(1)	IF A < 6 THEN A < 5 + 1
P	(2)	A < 6
1.2AA*	(3)	A < 5 + 1

To use AA: (1) Type the line number of the conditional, then a period.

(2) Type the line number of the antecedent.

(3) Type AA, then enter key.

2. AE - Add Equals

P	(1)	A = B
1AE :-3	(2)	A + (-3) = B + (-3)

To use AE: (1) Type the line number, AE, then enter key.

(2) After the :, type the term, then enter key.

3. AI - Additive Inverse Axiom

AI		A + (-A) = 0
A: 2	(1)	2 + (-2) = 0

To use AI: (1) Type AI, then enter key.

(2) Give the value you want for the A.

4. AL - Associate Addition Left

This is another shortcut way to use the AS axiom.

	(1)	8 + 1 = 7 + (1 + 1)
1AL2	(2)	8 + 1 = (7 + 1) + 1

To use AL: (1) Type the line number on which you want to associate left.

(2) Type AL.

(3) Type the occurrence number of the + you want to associate around.

---

*Student responses are underlined.

5. AR - Associate Addition Right
This is a shortcut way to use the AS axiom.

```
   P   (1)  8 + 1 = (7 + 1) + 1
1AR3   (2)  8 + 1 = 7 + (1 + 1)
```

To use AR: (1) Type the line number on which you want to associate right.

(2) Type AR.

(3) Type the occurrence number of the + you want to associate around.

6. AS - Associate Addition

```
AS          (A + B) + C = A + (B + C)
A: 3
B: 4
C: 5   (1)  (3 + 4) + 5 = 3 + (4 + 5)
```

To use AS: (1) Type AS, then the enter key.

(2) When the teletype asks A:, type the value you want substituted for A. Do the same for B and C.

7. CA - Commute Addition
This is the shortcut way to use the CA axiom.

```
   P   (1)  A + B = A + (9 + 1)
1CA3   (2)  A + B = A + (1 + 9)
```

To use CA: (1) Type the line number on which you want to commute addition.

(2) Type CA.

(3) Type the occurrence number of the +.

8. CE - Commute Equals

```
       (1)  IF A = 7 + 1 THEN A = 8
1CE2   (2)  IF A = 7 + 1 THEN 8 = A
```

To use CE: (1) Type the line number on which you want to commute equals.

(2) Type CE.

(3) Type the occurrence number of the = .

Note: On rules that operate on one line only, omitting the line number tells the computer to apply the rule to the preceding line; CM, AE, and SE are rules to which this holds.

9. CM - Commute Multiplication
This is the shortcut way to use the CM axiom.

P	(1)	$9 \times (A \times C) = 9 \times (C \times A)$
1CM3	(2)	$9 \times (A \times C) = (C \times A) \times 9$

To use CM: (1) Type the line number on which you want to commute multiplication.

(2) Type CM.

(3) Type the occurrence number of the × you want to commute around.

10. CP - Conditional Proof

P	(1)	IF R THEN S
P	(2)	IF S THEN Q
WP	(3)	R
1.3AA	(4)	S
2.4AA	(5)	Q
3.5CP	(6)	IF R THEN Q

To use CP: (1) Type the line number of the working premise, then a period.

(2) Type the line number of the consequent.

(3) Type CP, then enter key.

Notice that the working premise and all lines that depend upon it are indented.

11. DD - Deny Disjunct

P	(1)	R OR Q
P	(2)	NOT Q
1.2DD	(3)	R

To use DD: (1) Type the number of the line that has a disjunction on it.

(2) Type a period followed by the number of the line that has the negation of one of the disjuncts on it.

(3) Type DD, then enter key.

12. DE - Divide Equals

```
   P   (1)  A = B
 1DE
: 9+1  (2)  A / (9 + 1) = B / (9 + 1)
```

```
   P   (1)  A = B
   P   (2)  NOT C = 0
 1DE
: C    (3)  A / C = B / C
```

To use DE: (1) Type the line number on which you want to divide equals.

(2) Type DE, then enter key.

(3) After the :, type the term by which you want to divide.

Note: You can't divide by zero. If you want to divide a term like A + B, you must have NOT A + B = 0 on a line. The student must observe this himself, for the computer won't check this for him. (The curriculum was written in this way to save the student time in the proofs of certain theorems.)

13. DL - Distributive Law

```
DL                A × (B + C) = (A × B) + (A × C)
A: 1
B: C+7
C: 2    (1)  1 × ((C + 7) + 2) = (1 × (C + 7)) + (1 × 2)
```

To use DL: (1) Type DL, then enter key.

(2) Give the values you want for A, B, and C.

14. DLL - Delete the last line

```
   P   (1)  A = B
1CE1   (2)  B = A
DLL
DLL
```

YOU MAY NOT DELETE LINE 1. LINE 1 IS A PREMISE.

To use: Type DLL, then the enter key.

Note: DLL deletes the last line typed unless it is a premise.

15. DN - Double Negation

P	(1)	A = 3 + 1
1DN	(2)	NOT (NOT A = 3 + 1)
2DN	(3)	A = 3 + 1

With double negation you can add two negation signs to a sentence or take them away.

To use DN: (1) Type the number of the line to which you want to apply DN.

(2) Type DN, then enter key.

16. FC - Form a Conjunction

P	(1)	9 = 8 + 1
P	(2)	8 < 9
1.2FC	(3)	9 = 8 + 1 & 8 < 9
2.1FC	(4)	8 < 9 & 9 = 8 + 1

To use FC: (1) Type the number of the line that has the left conjunct on it, then a period.

(2) Type the number of the line that has the right conjunct on it.

(3) Type FC, then enter key.

17. FD - Form a Disjunction

P	(1)	R
1FD	(2)	R OR (Q)

To use FD: (1) Type the number of the line to which you want to apply FD.

(2) Type FD, then enter key.

(3) After OR (, type in a formula and a right parenthesis, then enter key.

18. FIN - Finish

```
     P   (1)  A < B
     P   (2)  B = C + 1
1.2RE1   (3)  A < C + 1
FIN
```

To use: Type FIN, then the enter key.

Note: Whenever you are finished working, type FIN and the program will log you off the computer.

19. FR - Fraction Axiom

```
FR          A / B = A × (1 / B)
A: 1
B: 2   (1)  1 / 2 = 1 × (1 / 2)
```

To use FR: (1) Type FR, then the enter key.

(2) Type the values you want for A and B.

Note: B cannot be 0 (zero), since division by zero is not defined.

20. IP - Indirect Proof

```
     Derive  NOT 1 = A

     P   (1)  A = 0
    WP   (2)      1 = A
2.1RE1   (3)      1 = 0
U        (4)      NOT 1 = 0
2.3.4IP  (5)  NOT 1 = A
```

To use IP: (1) Type the line number of the working premise, then a period.

(2) Type the two line numbers of the lines that deny each other. Put a period between them.

(3) Then type IP, enter key.

21. LC - Left Conjunct

```
  P   (1)  A = 2 & A = 1 + 1
1LC   (2)  A = 2
```

To use LC: (1) Type the line number from which you want the left conjunct.

(2) Type LC, then enter key.

22. LT - Logical Truth

LT
: (A + B) + C (1) (A + B) + C = (A + B) + C

To use LT: (1) Type LT, then the enter key.

(2) After the :, type the term you want, enter key.

23. ME - Multiply Equals

P (1) A = B
1ME
: 3 (2) A × 3 = B × 3

To use ME: (1) Type the line number on which you want to multiply equals.

(2) Type ME, then enter key.

(3) After the :, type the term by which you want to multiply.

24. MI - Multiplicative Inverse Axiom

MI A × (1/A) = 1
A: 2 (1) 2 × (1/2) = 1

To use MI: (1) Type MI, then enter key.

(2) Type the value you want for A.

Note: A cannot be 0 (zero), since division is not defined.

25. ML - Associate Multiplication Left

P (1) 10 × 6 = 10 × (6 × 1)
1ML2 (2) 10 × 6 = (10 × 6) × 1

To use ML: (1) Type the line number on which you want to associate.

(2) Type ML.

(3) Type the occurrence number of the X.

26. MR - Associate Multiplication Right

P	(1)	$10 \times 6 = (10 \times 6) \times 1$
1MR3	(2)	$10 \times 6 = 10 \times (6 \times 1)$

To use MR: (1) Type the line number on which you want to associate.
(2) Type MR.
(3) Type the occurrence number of the X.

Note: 25 and 26 are shortcut ways to use the MS axiom.

27. MS - Associate Multiplication

MS $(A \times B) \times C = A \times (B \times C)$
A: 1
B: 2
C: B (1) $(1 \times 2) \times B = 1 \times (2 \times B)$

To use MS: (1) Type MS, then enter key.
(2) Give values for A, B, and C.

28. MU - Multiplication by Unity Axiom

MU $A \times 1 = A$
A: B (1) $B \times 1 = B$

To use MU: (1) Type MU, then enter key.
(2) Type the value you want substituted for A.

Note: When a substitution is called for, any term may be used, not only numbers. Hence, C + D, C × D, A / B would all be acceptable.

29. N - Negative Number Axiom

N $A + (-B) = A - B$
A: 1
B: 2 (1) $1 + (-2) = 1 - 2$

To use N: (1) Type N, then the enter key.
(2) Give the values you want for the A and B.

30. ND - Number Definition

ND6 (1) 6 = 5 + 1

To use ND: (1) Type ND.

(2) Then type the number, enter key.

31. RC - Right Conjunct

P (1) A = 2 & A = 1 + 1
1RC (2) A = 1 + 1

To use RC: (1) Type the line number from which you want the right conjunct.

(2) Type RC, then enter key.

32. RE - Replace Equals (short form)

P (1) A < C + C
P (2) 9 + 1 = C
2CE1 (3) C = 9 + 1
1.3RE2 (4) A < C + (9 + 1)

To use RE: (1) Type the number of the line you want to replace, then a period.

(2) Type the number of the line that has the replacement equation.

(3) Type RE.

(4) Type the occurrence number of the term that you want replaced, then the enter key.

Note: In the example above we had to commute equals before we used RE. Remember that in the replacement equation the term to be replaced must be on the left.

33. RQ - Replace Equals (long form)

```
  P        (1)  A < C + C
  P        (2)  C = 9 + 1
1RQ
REP: C,2
 BY: 9+1  (3)  A < C + (9 + 1)
```

To use RQ: (1) Type the number of the line in which you want to replace a term, RQ, then the enter key.

(2) The computer types REP: and expects you to type the term you want to replace and its occurrence number.

(3) The computer types BY: and you type the new term.

Note: Remember that you can only replace one term by another after you have proved them to be equal.

34. SE - Subtract Equals

```
  P   (1)  A = B
1SE
: 3   (2)  A - 3 = B - 3
```

To use SE: (1) Type the line number SE, then enter key.

(2) After the :, type the term, then enter key.

35. TH - Theorem

```
TH1          0 + A = A
A: 6   (1)   0 + 6 = 6
```

To use: (1) You type TH, the theorem number, and the enter key.

(2) The computer types the theorem and then requests a substitution for one of the variables. You type a term.

(3) When you have made substitutions for all the variables, the computer types the correct instance of the answer.

Note: This format applies to all theorems. You may only use a theorem, however, after you have proved it.

36. U - Unity Axiom

U (1) NOT 1 = 0

To use U: (1) Type U, then enter key. There are no substitutions to be made.

37. WP - Working Premise

WP (1) A < B

To use WP: (1) Type WP, then enter key.

(2) When the computer stops, you type in the working premise, then the enter key.

38. Z - Zero Axiom

```
Z              A + 0 = A
A: 4    (1)    4 + 0 = 4
```

To use Z: (1) Type Z, then the enter key.

(2) Give the value you want for A when the teletype prints A:.

FORMAT FOR COUNTEREXAMPLES

After Lesson 241 in the outline for the second-year material, students are taught to handle problems such as

DERIVE OR FIND A COUNTEREXAMPLE:

Q

P (1) IF S THEN R

P (2) R

P (3) S OR Q

The program is constructed so that the student may type either the instruction DER to obtain the subprogram for deriving theorems or CEX to obtain the subprogram for making truth assignments and finding counterexamples. What follows is an example of how the CEX option works with respect to the same problem above. Input by the student is indicated by underlining.

CEX YOU ARE LOOKING FOR A COUNTEREXAMPLE. THUS, THE CONCLUSION MUST BE FALSE AND THE PREMISES TRUE.

NOW ASSIGN CONSISTENT TRUTH VALUES TO THE SENTENCE LETTERS.

T S

F Q

T R

LET US CHECK TO SEE IF YOUR TRUTH ASSIGNMENT MAKES THE PREMISES TRUE AND THE CONCLUSION FALSE.

T IF S THEN R

T R

T S OR Q

YOUR ASSIGNMENT MAKES ALL THE PREMISES TRUE. LET'S CHECK THE CONCLUSION.

F Q

CORRECT

DERIVE OR FIND A COUNTEREXAMPLE:

S OR NOT R

P (1) IF NOT NOT Q THEN NOT S

P (2) IF R THEN Q

CEX YOU ARE LOOKING FOR A COUNTEREXAMPLE. THUS, THE CONCLUSION MUST BE FALSE AND THE PREMISES TRUE.

NOW ASSIGN CONSISTENT TRUTH VALUES TO THE SENTENCE LETTERS.

F S

(If the student were to reply here with T, then the program would eventually give him an error message such as the one at the end of the next example.)

T Q

T R

(Now the program will begin to present the student with subformulas as follows.)

LET'S COMPUTE TRUTH VALUES FOR ALL SUBFORMULAS AND THEN THE FORMULA ITSELF.

F NOT Q (At this point, input T would result in an error message.)

T NOT NOT Q

T NOT S

T IF NOT NOT Q THEN NOT S

T IF R THEN Q

YOUR ASSIGNMENT MAKES ALL THE PREMISES TRUE. LET'S CHECK THE CONCLUSION.

F NOT R

F S OR NOT R

CORRECT

The final example below shows how the program operates if the student erroneously tries the CEX option instead of the DER one.

DERIVE OR FIND A COUNTEREXAMPLE:

IF S THEN Q & R

P (1) Q

P (2) R

CEX YOU ARE LOOKING FOR A COUNTEREXAMPLE. THUS, THE CONCLUSION MUST BE FALSE AND THE PREMISES TRUE.

NOW ASSIGN CONSISTENT TRUTH VALUES TO THE SENTENCE LETTERS.

T Q

T R

F S

YOUR ASSIGNMENT MAKES ALL THE PREMISES TRUE. LET'S CHECK THE CONCLUSION.

T Q & R

T IF S THEN Q & R

THE CONCLUSION MUST BE FALSE. YOU MAY NOW EITHER TRY ANOTHER TRUTH ASSIGNMENT OR TRY TO DERIVE

IF S THEN Q & R.

HANDBOOK FOR

COMPUTER-ASSISTED INSTRUCTION IN PROGRAMMING: BASIC

HANDBOOK FOR

COMPUTER-ASSISTED INSTRUCTION IN PROGRAMMING: BASIC

BASIC, one of two self-contained CAI programming courses available for student use via the Stanford teletype network, was developed for IMSSS under a 1968 grant from the National Science Foundation. Prepared as a tutorial course by Phyllis Cole, it is designed for high school students with a minimal mathematics background.

1. Course Description

The course consists of 50 lessons, about one hour in length, plus summaries, reviews and self-tests. It is approximately a one-semester curriculum course. Separate homework sheets are available, together with a student manual that includes instructions for operating the instructional program and a glossary of terms used in the course. Supplementary materials may be obtained for your school from your Stanford representative.

The BASIC course does not require supervision or a trained teacher of programming. It would be advisable for the teacher and proctor to acquaint themselves with the operating procedures and overall content of the course.

2. Method of Operation

Instructions for the BASIC course and curriculum problems are typed on the Model-33 student teletype linked by telephone lines to the Stanford PDP-10 computer. The student is instructed to type his answers and to signal the end of his responses. The computer then analyses the student's responses, replies with corrections if necessary or proceeds to the next problem.

3. Curriculum Description

An outline of the BASIC course appears at the conclusion of this description. The lessons cover the following concepts of programming and use of computers:

1. An interactive timesharing executive system
2. An interpreter
3. Concept of a stored program
4. Debugging techniques

5. Labels and variables
6. Loops, including nested loops
7. Input and output
8. Subroutines

As the student works through the lessons, he writes, runs and debugs from 100-200 programs of increasing difficulty. The student is encouraged to evaluate his own performance and is in control of the order of his lessons.

Each lesson contains problems that present a concept with practice problems. At the end of the lesson there is an optional summary of that lesson; the summary is typed in an 8-1/2" x 11" format which the student can save as a permanent reference. Following the summary, there is an optional review section. The review, like the problems, is tutorial, not merely additional practice, and presents the lesson concepts from a different point of view. Thus the student may choose at any time to review any part of a lesson that he did not completely understand.

Cumulative overviews occur every six lessons and serve as a reminder of what has been taught; they indicate which of the topics covered are essential for subsequent material. Self-test lessons occur about every sixth lesson and, with the off-line optional homework, give the student and his teacher a basis for evaluating his progress. The total curriculum structure is illustrated in Figure 1.

A daily report of progress is available for every student enrolled in the BASIC course. Refer to REPORT program in the Proctor's Handbook to request reports.

A BASIC report would have the following information:

```
CLASS 28        TEACHER'S NAME      DATE
5 STUDENTS       SCHOOL NAME        GRADE 12

W - BASIC REPORT

LESSON     HOMEWORK     TEST     SUMMARY

2 - 5      0 - 0        0 - 0    4 - 1      210  STUDENT NAME
3 - 5      2 - 7        0 - 0    2 - 1      246  STUDENT NAME
4 - 4      2 - 6        0 - 0    2 - 1      223  STUDENT NAME
2 - 5      0 - 0        0 - 0    4 - 1      236  STUDENT NAME
7 - 17     5 - 5        1 - 11   7 - 7      274  STUDENT NAME
```

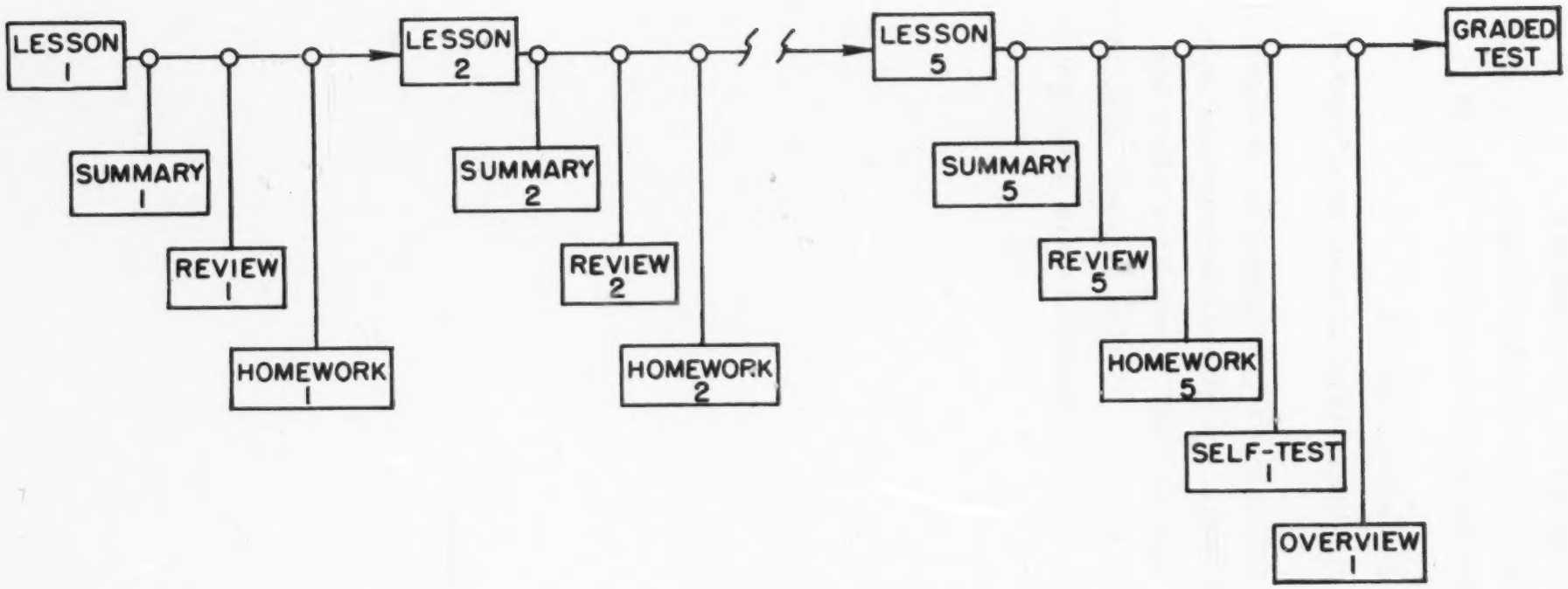


Fig. 1. Structure of the BASIC course. One lesson block, including five lessons (with summaries and reviews, self-test, overview lesson, homework, and graded test). Student decision points are marked with a circle. Optional lessons are shown below the main line. Homework is shown as optional, since a teacher may not wish to assign it. Beyond Lesson 5, review lessons are omitted.

Referring to the last student listed in the example:

1. He is on the seventh lesson, seventeenth problem.
2. He completed the five homework problems assigned for the fifth lesson.
3. He completed the eleven problems in Test 1.
4. He requested the summary for the seventh lesson as a preview of Lesson 1.

Again, no previous knowledge of computers, programming or algebra is necessary as a prerequisite for BASIC. A general mathematics background will suffice as topics are repeated and appropriate hints and explanations are embedded in the curriculum. Sample lessons, available on guest demonstration numbers, and sign-on procedures are detailed in the Proctor's Handbook.

List of Available BASIC Programming Lessons

L1 Introduction to the instructional program
L2 Using BASIC for arithmetic
L3 Solving problems
L4 Order of arithmetic operations
L5 Solving problems with more than 1 operation
L6 Self-test
L7 Overview of Lessons 1-5
L8 Decimals; some hints on debugging
L9 Debugging
L10 The "LET" command
L11 The "INPUT" command
L12 The "GO TO" command
L13 Self-test
L14 Overview of Lessons 8-12
L15 Comparing numbers
L16 The "IF-THEN" command
L17 More about "PRINT"
L18 Using 2 counters
L19 Traces
L20 Self-test
L21 Overview of Lessons 15-19
L22 The "FOR" command
L23 The "STEP" command
L24 Solving problems
L25 Loops with variable bounds
L26 Loops with "INPUT" or "IF" instructions
L27 Self-test
L28 Overview of Lessons 22-26
L29 The "READ" and "DATA" commands
L30 Solving problems
L31 Introducing exponents
L32 The "SQR" command
L33 The "DEF" command
L34 Self-test
L35 Overview of Lessons 29-33
L36 Neat output
L37 Patterns
L38 The "STOP" and "REM" commands
L39 The "GOSUB" and "RETURN" commands
L40 Equivalent programs
L41 Self-test
L42 Overview of Lessons 36-40
L43 Scientific notation
L44 Problems involving scientific notation
L45 Introducing nested loops
L46 Using nested loops
L47 "REALISTIC" programs. Flow charts off-line lesson
L48 Self-test
L49 Overview of Lessons 43-47
L50 How to learn more about BASIC

HANDBOOK FOR

COMPUTER-ASSISTED INSTRUCTION IN PROGRAMMING: AID

HANDBOOK FOR
COMPUTER-ASSISTED INSTRUCTION IN PROGRAMMING: AID

In 1968 IMSSS received funding from the National Aeronautics and Space Administration to design and produce a programming course using CAI. Algebraic Interpretive Dialogue (AID), a high-level algebraic language, was selected and developed into a self-contained, tutorial programming curriculum by Jamesine Friend. It is a program designed for the junior college student and requires at least one year of algebra as a background. The AID course uses more complex algebraic forms than does the BASIC programming course.

1. Course Description

The course consists of a set of 50 lessons, about one hour in length, plus summaries, reviews, tests, and extra-credit problems. A student manual, which includes instructions for operating the instructional program and a glossary of terms used in the course, is available by contacting your Stanford representative.

The computer-assisted instruction and supplementary manual constitute a completely self-contained course. The lessons are tutorial in nature, that is, no previous knowledge of computers or programming is necessary. The only prerequisite for the course is a good background in algebra, as supplied by three semesters of high school algebra.

2. Method of Operation

Computer-assisted instruction is given to the students by means of standard Model-33 teletypewriters, located in schools, which communicate by means of ordinary telephone lines with the PDP-10 computer located at Stanford. The problems are typed on the student's teletype by the computer and the student responds by typing his answers on the same teletype. After the computer analyzes the student's response, the student is informed whether his response was correct or incorrect, then he is given additional instruction and asked to respond again, or he is given a different problem.

The course does not require the supervision of a trained teacher of programming, but a one-day teachers' workshop should be given to acquaint

teachers with operating procedures and to provide them with an overview of the content of the course. For sign-on procedures, refer to the Proctor's Handbook.

Although the course is ordinarily used on a regularly scheduled basis in a college environment or training center, it is also well suited for an on-the-job training course for people working in association with a computer facility. Use by individuals can be on a nonscheduled basis or on a flexibly scheduled basis, since there are few time restrictions on the use of the computer; some students might prefer to spend several hours a day on the course, with the possibility that they could complete the course within a few weeks rather than distributing their lessons over several months.

3. Curriculum Description

The 50 lessons cover the following fundamental concepts of programming and the use of computers.

(1) An interactive timesharing executive system.
(2) An interpreter.
(3) Concept of a stored program.
(4) Debugging techniques.
(5) Labels and variables.
(6) Loops.
(7) Input and output.
(8) Computer storage, including both core and disk.
(9) Subroutines.
(10) Recursive functions.
(11) List sorting and table look-up routines.

The student is required to write and debug at least 50 programs, several of which are major programs for solving difficult algebraic problems. An outline of the course is included in this description of AID.

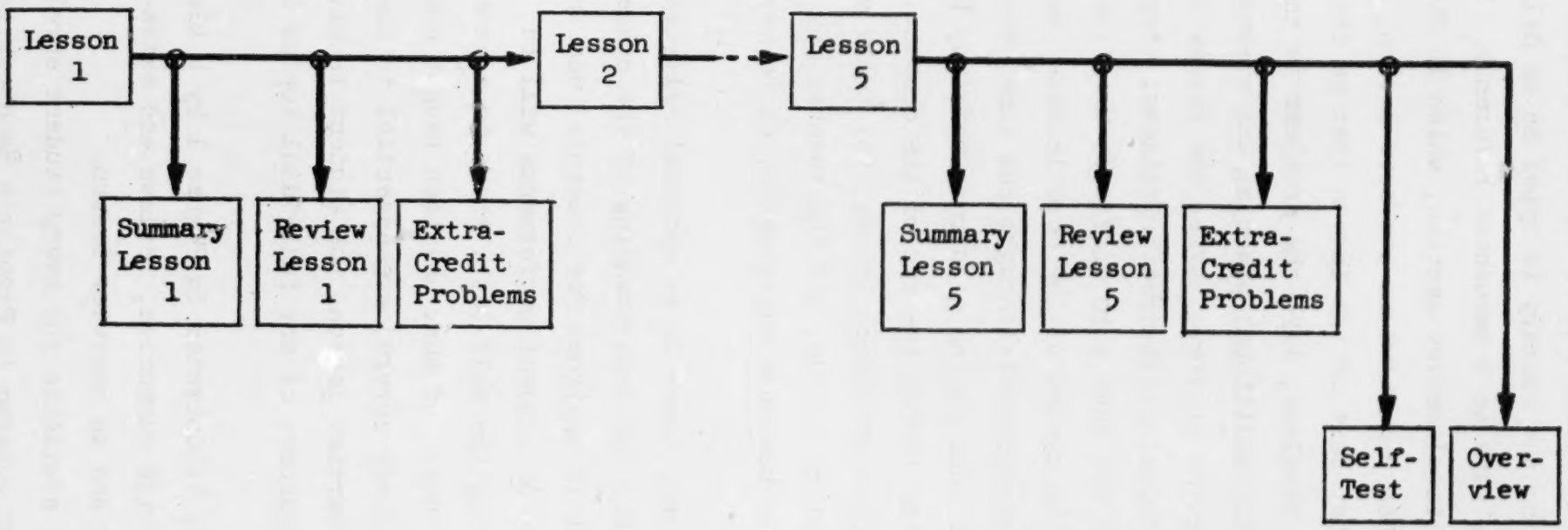
Each lesson covers one basic concept, varying in length from 50 to 200 problems and requiring about one hour for an average student to complete. A lesson contains three sections: a core lesson, a summary, and a review. Selected lessons contain an additional extra-credit section. The core lesson contains about 20 to 30 problems that present the concept

and supplies some practice problems. At the end of the core lesson there is an optional summary of the lesson; the summary is typed in an 8-1/2" x 11" format, which the student can save as a permanent reference. Following the summary, there is an optional review section, which is divided into several parts, one for each idea presented in the core lesson, so that the student may review only that part of the lesson that he did not completely understand. The review problems, like the problems in the core lesson, are tutorial, not merely additional practice, and present the ideas afresh from a different point of view. After the review section, there may be a short section of optional extra-credit problems; there are usually programming problems, which are much more difficult than the programming problems given in either the review or the core lesson. Most of the extra-credit problems require considerable thought and time, and the student is not expected to complete them during a current session, but may, instead, submit them at any time before the end of the course. Extra-credit problems are not supplied with each lesson, but there are at least 50 such problems in the entire course, and the teacher may wish to require some of these problems as homework assignments, or he may use them as tests.

After each group of five lessons, there is an optional self-test designed to help the student evaluate his understanding of the concepts presented to date. Since this test is designed for students' use and not for grading purposes, no report on student performance will be available to the teachers. Following the self-test, there is a general overview lesson that reminds the student of what has been taught and informs him which of the topics already covered are essential to the subsequent material. During the overview lesson, the student is given the opportunity to review entire lessons, or any individual topics from preceding lessons.

The structure of the course is illustrated in Figure 1 by a block diagram of a set of five lessons (with summaries, reviews and extra-credit problems), followed by a self-test and an overview lesson.

A daily report of progress is available for every student enrolled in the AID course. Refer to REPORT program in Proctor's Handbook to request reports.



One lesson block is shown, including 5 lessons (with Summaries, Reviews, and Extra-Credit Problems), Self-Test, and Overview Lesson.

Student decision points are marked ⊸ .

Optional lessons are shown below the main line.

Fig. 1. Structure of course.

CLASS 2 TEACHER'S NAME DATE
4 STUDENTS SCHOOL NAME GRADE 14

Q - AID REPORT

LESSON	REVIEW	EX.CREDIT	SUMMARY		
1 - 2	0 - 0	0 - 0	0 - 0	771	STUDENT NAME
7 - 10	3 - 1	2 - 1	8 - 1	774	STUDENT NAME
1 - 2	0 - 0	0 - 0	0 - 0	776	STUDENT NAME
8 - 10	2 - 1	7 - 1	7 - 1	781	STUDENT NAME

Referring to the last student in the example:

1. The student is in the eighth lesson, tenth problem.
2. He requested and completed a review of lesson two, but has not requested reviews for following lessons.
3. He requested and completed the extra-credit problems after the seventh lesson.
4. He has requested a summary of the last lesson he competed, lesson seven.

In general, students are expected to have had some previous work with algebra, but it is not assumed that the level of skill is high. All topics are reviewed at appropriate times for the student who needs a refresher. Sample lessons, available on guest demonstration numbers, and sign-on procedures are detailed in the Proctor's Handbook.

List of AID Lessons

L1 How to use the teaching program
L2 Using AID for arithmetic
L3 Order of arithmetic operations
L4 Exponents, scientific notation
L5 The "SET" and "DELETE" commands
L6 Self-test
L7 Review of Lessons 1-5
L8 The "LET" command
L9 AID functions
L10 Indirect steps, the "DO" command, the "FOR" clause
L11 PARTS
L12 The "DEMAND" command
L13 Self-test
L14 Review of Lessons 8-12
L15 Relations, "IF" clauses
L16 The "TO" command
L17 Debugging techniques: traces
L18 The indirect use of "DO"
L19 How to write and debug a program. Permanent storage.
L20 Self-test
L21 Review of Lessons 15-19
L22 The "FORM" statement
L23 Loops
L24 Loops with variables in the exit condition
L25 Loops and "FOR" clauses
L26 Loops with a "DEMAND" command
L27 Self-test
L28 Overview of Lessons 22-26
L29 Absolute values
L30 SIN(X) and COS(X)
L31 Exponential and logarithmic functions
L32 Lists of numbers
L33 Using loops with lists of numbers
L34 Self-test
L35 Overview of Lessons 29-33
L36 Nested loops and decrementing counters
L37 SUM, PROD, MAX, MIN
L38 Arrays
L39 More about arrays and lists
L40 Conditional definitions of functions
L41 Self-test
L42 Overview of Lessons 36-40
L43 Recursive functions
L44 "AND", "OR" and "NOT": truth tables
L45 TV(X) and the FIRST function
L46 LET and Boolean expressions plus debugging tools
L47 More standard AID functions
L48 Self-test
L49 Overview of Lessons 43-47
L50 Programming problems

CAI BASIC ENGLISH HANDBOOK

CAI Basic English,* developed by the Computer Curriculum Corporation of Palo Alto, Calif., is a CAI program that provides training in problem areas of grammar and usage for twelfth grade and beginning community-college students. It is compatible with standard handbooks and textbooks and can be used in conjunction with classroom work in writing skills.

CAI Basic English is self-instructional, self-paced, and individualized skill training. It cannot replace the teacher in conveying an appreciation of great literature or the finer points of style; these goals are far beyond the purpose of the program. It can, however, lift much of the burden of grammar instruction, drills, and homework from the teacher's shoulders by providing specific remediation in certain errors in writing.

The program is designed to diagnose and correct the twelve most commonly noted gross errors of sentence composition, and can relieve the teacher of the burden of diagnosing, drilling, and testing basic language concepts that should have been learned earlier in the student's academic life. CAI Basic English does not, however, teach the student to form sentences into acceptable paragraphs, themes, or essays. The task of teaching organization, paragraph structure, coherence, style, content, and all the other skills that go into the creation of good prose remains uniquely and entirely that of the teacher.

Students in the CAI Basic English program are assigned to a terminal for approximately forty-five minutes a day. Each student receives training in just those parts of the program he needs. Continual performance checks throughout the program allow the student to skip or recycle through parts of the instructional sequence as required. Information about student performance, both for individuals and for the group as a whole, is made available to the teacher at frequent intervals.

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1. Program Objectives

The major objective of CAI Basic English is to enable the student to write English sentences that are free of gross errors. To achieve this, the program teaches the student to recognize and correct specific writing errors.

The gross errors treated are the following:

1. Run-on sentences
2. Sentence fragments
3. Incorrect principal parts of the verb
4. Confusion of adjectives and adverbs
5. Lack of agreement between the subject and verb
6. Lack of agreement between the pronoun and its antecedent
7. Incorrect case of pronouns
8. Vague or indefinite pronominal reference
9. Dangling elements
10. Misplaced modifiers
11. Errors in comparative forms of adjectives and adverbs
12. Double negatives

2. Program Structure

The curriculum is organized into a matrix of strands and topics through which the student proceeds by a route determined by his individual remedial needs (Figure 1). The diagnostic entry examination provides the information needed to decide whether the student needs all, part, or none of the program. If the student is assigned CAI Basic English, he must begin with the introductory lessons that teach him how to operate the terminal.

Introductory lessons, given at the terminal before the student begins work in the program, introduce the student to the special features of the terminal being used. They also acquaint him with capitalization conventions, the type and manner of question presentation, and other features of the CAI Basic English program.

Once a student begins the program, he follows a course of instruction that takes him to the level of skill needed in each of the twelve gross-error categories. The program is composed of three strands

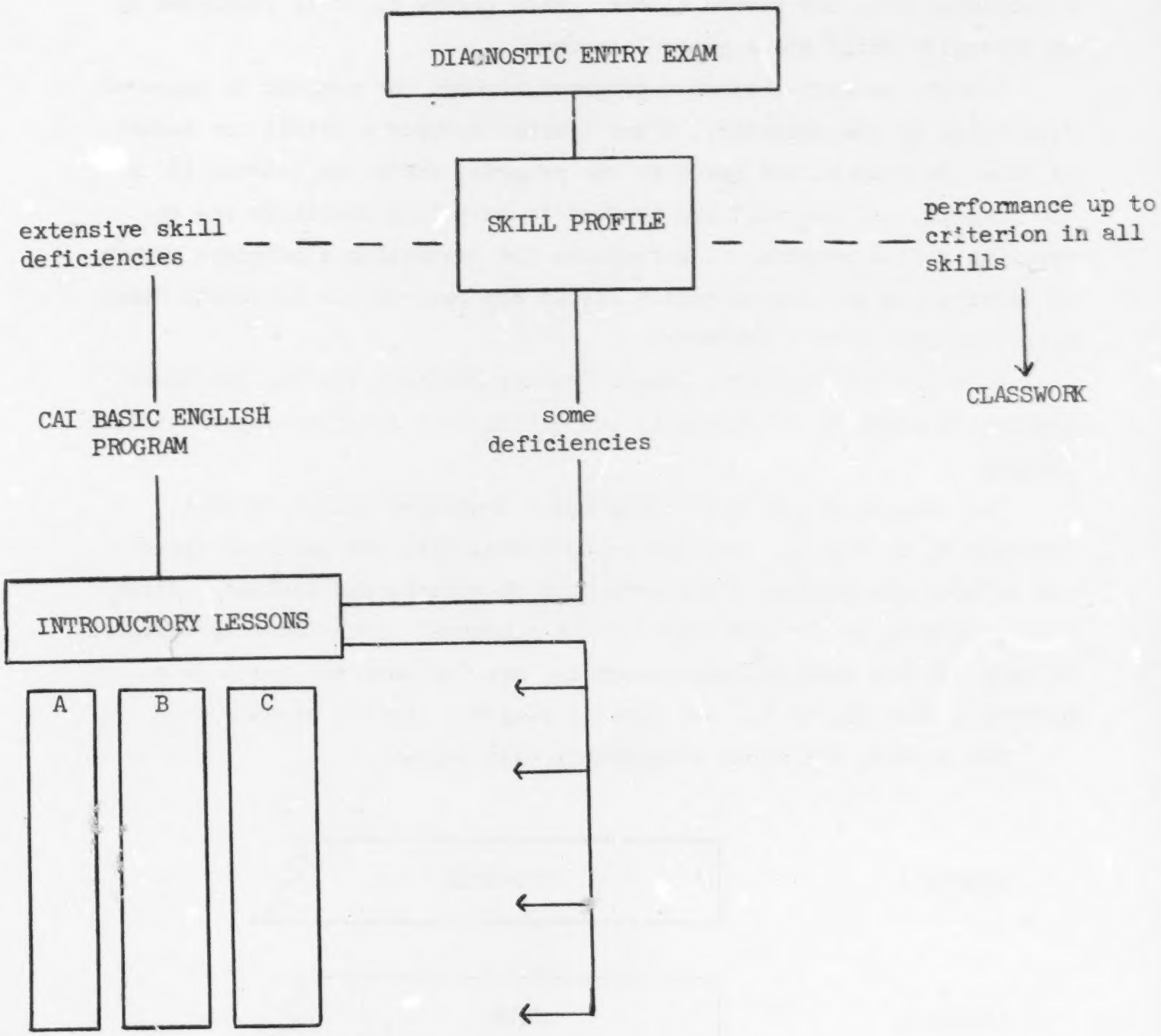


Fig. 1. CAI Basic English program structure: Entry into the program.

coordinated into ten review blocks. Each review block is concluded by an intensive drill and a general review.

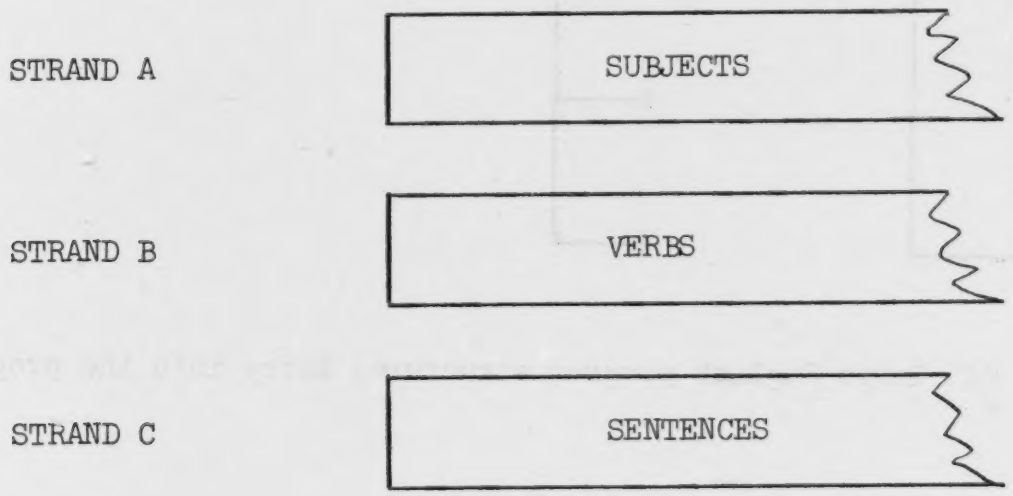
Reports on each student's progress through the program is prepared frequently by the computer. These teacher's reports detail the amount of time the student has spent on the program, where the student is in the program, and how well the student is answering questions and responding to the program. Instructions for requesting a progress report or viewing a guest demonstration lesson are part of the Proctor's Handbook included in this Handbook.

A Manual for Teachers, plus a Student Handbook for the CAI Basic English Program, is available by contacting your Stanford representative.

Strands

The program consists of three major sequences called strands (Strands A, B, and C). Strands A and B deal with the parts of speech and related grammatical structures such as phrases and clauses. Strand C concentrates on the structure of the sentence. The student progresses through all the strands simultaneously, weaving back and forth in a pattern determined by his own rate of progress in each strand.

The strands are shown diagrammatically below.



Topics

The strands are series of topics, each of which contains two to five related lessons. Each topic ends with a comprehensive test of from 12 to 24 problems dealing with the objectives of that topic. If

the student fails to answer at least 75 percent of the comprehensive test problems correctly, he repeats the topic. After taking the comprehensive test for a second time, the student automatically progresses to the next topic.

The objectives of the topics interrelate for the remediation of the 12 gross errors. Each student takes all the topics leading toward his particular gross errors identified by the Basic English Pre-Test.

While the topics within a strand are arranged sequentially, they are also designed to interrelate across the strands so that the student's work on one strand relates to and reinforces his work on the others. For example, while Strand A deals with the formation of comparative and superlative adjectives, Strand B deals with the use of verb forms with adjectives, and Strand C covers the noun-linking verb-subject complement sentence structure.

Review Blocks

Related topics in each of the three strands are coordinated into review blocks. The student must complete all the topics in one block before proceeding to the intensive drill and general review sections that complete the block.

A typical review block is shown below.

REVIEW BLOCK 4

STRAND A	STRAND B	STRAND C
A4.7 Adjectives	B4.7 Linking Verbs 1	C4.7 Subject Complements 1
A4.8 Adjective Comparisons	B4.8 Linking Verbs 2	C4.8 Subject Complements 2

---------- INTENSIVE DRILL ----------

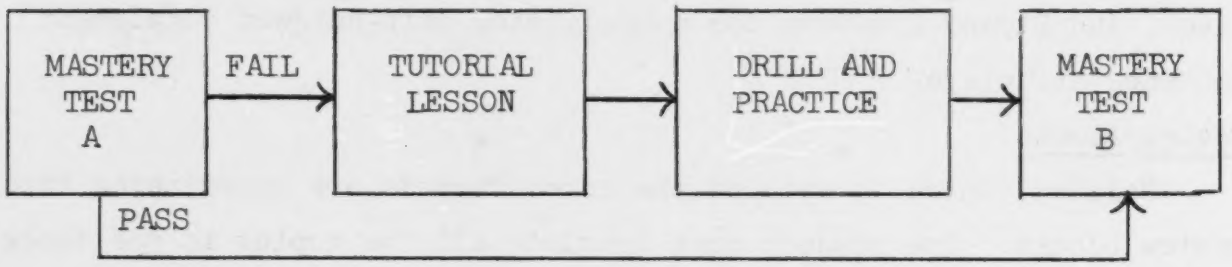
R4A Pronoun Case
R4B Pronoun Case
R4C Comparing Adjectives Correctly
R4D Comparing Adjectives Correctly

---------- GENERAL REVIEW ----------

Lessons

Every topic contains from two to five related lessons. Each lesson within a topic begins with a short mastery test, followed by a detailed explanation called a tutorial. The lesson concludes with a group of drill-and-practice problems.

The initial mastery test determines whether the student has already attained the behavioral objective of the lesson. If a student passes the mastery test, he goes directly to the next lesson. If the student does not pass the mastery test, he is given the tutorial and the drill-and-practice problems. The routing function of the mastery test may be shown diagrammatically as follows:



Tutorial

The tutorial is the teaching section of the lesson. Entry into the tutorial is possible only after an error is made on the mastery test or in a general review. Thus the tutorial is studied only by those who can learn something from it.

In a typical tutorial, an explanation is followed by opportunities for the student to respond. The computer gives the correct answer immediately after the student types his answer.

Drill and Practice

The drill-and-practice problems follow the tutorial. Everyone who takes the tutorial also takes the drill-and-practice problems, since the function of this section is to give the student practice in applying the concepts he has just learned to a variety of commonly met sentence patterns.

In the drill-and-practice section, the student types his answer to an example and the computer immediately follows with the right answer.

There is no time penalty; however, the computer does print "timed out" if the student takes an exceptionally long time to answer.

Intensive Drill

The intensive drill section immediately follows the completion of all work in a review block. It is designed to provide extended practice in skills related to specific gross errors.

For example, after learning about subject pronouns, subject-verb agreement with regular verbs, compound subjects, the present and past tenses of "be," and subject-verb agreement with "be," the student receives an intensive drill directed toward the elimination of the gross error of lack of agreement between subject and verb.

The intensive drill is composed of eighty new problems. The student answers each problem and receives immediate confirmation after each response.

General Review and Individualized Review

Each review block concludes with a general review section. The general review is made up of one or two items taken from the drill-and-practice section of each lesson in each topic in the block. The computer maintains a table of errors made on the general review items for use in scheduling individualized review sessions.

The student goes on to new material after completing the general review. After each day's new work, the computer consults its table of errors and presents the tutorial and drill-and-practice sections that contain problems which were answered incorrectly on the general review. These reassignments of learning material are called individualized review because the student reviews only those lessons he needs.

The individualized review must be completed before the student can take the next general review. Thus, if any reassignments are left after the student has gone through all the material in the next block, the computer will present only individualized review until all those lessons have been completed. At that point the student will receive the intensive drill and general review sections for the current block.

For example, if the student makes errors in items drawn from A5.9A, A5.9B, B5.10B, and C5.10C in the general review section of Review Block 5,

he must take the tutorial and drill-and-practice sections of these four lessons again. He is given about 5 minutes of instruction in these reassignments after each day's work on the material in Review Block 6. The tutorial and drill and practice from Lesson A5.9A are presented after his first day's work. If the student completes them with time to spare, he begins the next individualized review lesson; otherwise, the tutorial and drill and practice from A5.9B are given after his second day's work, and so on. If there are remaining individualized review assignments in the computer's table when all the lessons in Block 6 are finished, the student must take the remedial work before he receives the intensive drill for Review Block 6. This situation could arise if the student knew very little material in Review Block 5 and very much in Review Block 6, in which case he might complete Review Block 6 in a few days by passing all the mastery and comprehensive tests and still have his reassignments for Block 5 to complete.

Diagnostic Entry Examination

All entering students take an initial placement examination to determine the extent of their need for skill training in recognizing and correcting gross errors in sentence structure. The examination is made up of two parts:

Part I consists of objective items in a multiple-choice format. This pretest is provided with the Basic English course.

Part II is a writing sample. It serves as an independent check of the student's writing skills. This sample is to be given and evaluated by the course instructor.

Scoring the objective items may be done by computer or by hand. A total score, plus 12 subscores representing the 12 gross errors, gives the instructor a profile of the student's strengths and weaknesses. The writing sample is scored by the instructor on the basis of the presence or absence of the 12 gross errors in the student's writing.

These combined tests yield three categories of students: those who go on to regular classwork without CAI, those who take only part of the CAI program, and those who take the entire CAI program.

Basic English Post-Test

A Basic English Post-Test is provided with the CAI Basic English program in order to test the skills acquired by students who have completed their work in the Basic English program. It is similar to the Basic English Pre-Test in structure and content.

Complete grading procedures for both the Basic English Pre-Test and the Basic English Post-Test will be given with the respective tests.

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PROCTOR'S HANDBOOK

This handbook is a reference guide for proctors and teachers involved in the Stanford CAI teletype programs and provides step-by-step instructions on the use of student programs and teacher's reports. Information on guest demonstrations is included, as well as suggestions for handling teletype problems. For more specific information concerning curriculum content and teletype maintenance, please refer to the appropriate chapters within this Handbook.

1. Note to Proctors

Because your role is new in the educational field and it has been difficult to define your position, you may have questions of how to best fulfill your role. Based on our experience over the past six years and on our observation of personnel in similar roles, it is possible to identify some of the duties of a proctor that promote a successful CAI program.

Observation and Assistance = T.L.C.* Computers cannot perform alone. Students, particularly the younger children, need your patient introduction to the teletype, plus your guidance and encouragement. CAI is an exciting, positive experience for them. Show the students you are interested in their progress and achievements. As in the classroom, your attitude sets the tone for the CAI program in your school.

2. Scheduling

As in any area of special education, scheduling is necessary for an efficient program and is a unique assignment within each school. Scheduling within each school is based on the number of teletypes and the number of students participating in the CAI program. In schools with one or two terminals a successful procedure is the following. List the names on the blackboard indicating the order of each student's turn on the teletype. A card with several names may serve as a pass for the student to leave the classroom. As each student returns, he hands the

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*Tender loving care.

card to the next person on the list. In schools with a greater number of terminals, larger portions of a class may attend the sessions at one time.

Check with supervisory personnel about specific hours and available time for CAI within the school day. Know the time limits, if any, of the school curriculum programs. Confer with teachers. Establish a time for each class or group of students and maintain that schedule.

3. Enrollment

Curriculum programs available for student use are:

Program	Curriculum ID letter
Math Strands	S
Logic	L
Language Arts	G
Reading	R
BASIC	W
AID	Q
English	E

Usually it is the responsibility of the proctor to prepare the student roster. When preparing this list watch for (a) correct spelling of student's name, (b) inclusion of middle name or initial for students with duplicate first names (JOHN D., JOHN E.), (c) grade level, and (d) teacher's name. Send the list to Mrs. Barbara Anderson via the teletype TALK program, the data phone or by mail at IMSSS-Pine Hall, Stanford University, Stanford, California 94305. She will assign student numbers and flag each student for specific curriculum programs. Each program is identified with the appropriate ID letter, which is typed preceding the student number (e.g., S4040 or W4040). Any new student number assignments, name changes or curriculum program enrollment request should also be sent to Mrs. Anderson.

When you receive your completed name list from Mrs. Anderson, double check its accuracy for spelling and individual details.

4. Sign-on Procedure

Children have little difficulty learning to operate the teletypes. Paper replicas of the keyboard give students classroom practice before they use the teletype. Each teacher can easily determine the amount of

preparation necessary. After students receive an explanation of the teletype and become acquainted with sign-on procedures, they experience great pleasure in their individual accomplishments. The younger children will need the proctor's help and approval. This is a "first" for them too. Help all students to take pride in this new venture.

To start the Model-33 teletype, the "line-local" knob on the right front panel of the machine must be at "line." To initiate a student program, first press the BREAK (START) key on the right side of the keyboard, then the space bar. The computer response will be

HI
PLEASE TYPE YOUR NUMBER AND NAME.

Program ID Letter	Student Number	(space)	First Name	(space)

The program will respond with the student's last name. Type the space bar if the last name is correct. Specific procedures for the various programs follow.

S - MATH STRANDS PROGRAM

A program providing supplementary individualized instruction in elementary mathematics for Grades 1-7. Students must be enrolled for "S" curriculum program.

To sign on

Student:	Press BREAK (START) key Press Space Bar
TTY response:	HI PLEASE TYPE YOUR NUMBER AND NAME
Student types:	S Student Number (space) First Name (space)
TTY response:	Student's last name
Student types:	Space Bar
TTY response:	Time Date TTY number Program begins
Student types:	Answers to problems

CURRICULUM CONTROL CHARACTERS

ACTION	CONTROL CHARACTERS
To type "<,>,=,+,-"	Press shift key and desired symbol

When answering mathematics problems, there are two methods of typing answers: vertical and horizontal.

Method 1: Vertical problems are presented in the form of columns, e.g.,

```
 23
+6
---
```

In this case, the answer (29) must be typed starting with the units digit (9), then the tens digit (2). After the units digit is typed, the teletype will back up to the position for the tens digit. Thus the answer is typed in reverse order. Vertical problems are easily identifiable by the column form they take.

Method 2: Horizontal problems are typed in the usual manner, e.g.,

3 + ... = 41

The answer (38) is typed 3 then 8.

To sign off

The program will sign off automatically according to class time limits or may be stopped at any time by

Typing: CTRL key and Z

To receive a daily report of student progress, see REPORT program.

L - LOGIC PROGRAM

The Logic program, suitable for the junior high school student, is a tutorial course designed to teach skills in constructing derivations of expressions in sentential logic and elementary algebra. Students must be enrolled for "L" program curriculum.

To sign on

Student:	Press BREAK (START) key Press Space Bar
TTY response:	HI PLEASE TYPE YOUR NUMBER AND NAME.
Student types:	L Student Number (space) First Name (space)
TTY response:	Student's last name
Student types:	Space Bar

TTY response:	Time Date TTY number The program begins where previous lesson was terminated unless problem grouping requires earlier restart.	

CURRICULUM CONTROL CHARACTERS

ACTION	CONTROL CHARACTERS
End of answer	Type ENTER (or ESC or ALT MODE) key
Hint	Type HINT
Erase single characters (spaces are characters)	Type RUBOUT key
Erase entire line	Type CTRL key and U

Refer to Logic and Algebra Programs for command characters, page 12 ff.

To sign off

The length of a lesson is determined by the individual class, however, most lessons are set between 10 and 15 minutes. To terminate a lesson before the automatic sign off:

Student types: FIN (ENTER)

For a report on student progress, see REPORT program.

G - LANGUAGE ARTS PROGRAM

A curriculum program designed for deaf students at the junior high school level providing drills in grammar and language development. Students must be enrolled for "G" program curriculum.

To sign on

Student:	Press BREAK (START) key Press the Space Bar
TTY reponse:	HI PLEASE TYPE YOUR NUMBER AND NAME
Student types:	G Student Number (space) First Name (space)
TTY response:	Student's last name
Student types:	Space Bar
TTY response:	Time Date TTY number HELLO (student's name) Program begins with introductory lesson and thereafter, where previous lesson was terminated.

If it becomes necessary to interrupt the programmed sequence of lessons, type CTRL key and J (or LINEFEED). The program will request name of lesson desired. (Refer to outline of lessons.)

CURRICULUM CONTROL CHARACTERS

ACTION	CONTROL CHARACTERS
End of answer	Type RETURN key
Tell the answer	Type CTRL key and G
Skip this exercise	Type CTRL key and H
Go to choice point	Type CTRL key and J or LINEFEED key
Erase entire line	Type RUBOUT key
Repeat the problem	Type CTRL key and A

To sign off

The G program has no set time limit to terminate a lesson:

Student types: CTRL key and Z

TTY response: Sign-off message

For a report of student progress, see REPORT program.

R - READING PROGRAM

A program in initial reading for Grades 1-3 and remedial intermediate grades. The curriculum provides individualized drill in the basic skills of beginning reading. This program is available only in those schools equipped with audio channels. Students must be enrolled for "R" program curriculum.

To sign on

Student:	Press BREAK (START) key Press Space Bar
TTY response:	HI PLEASE TYPE YOUR NUMBER AND NAME
Student types:	R Student Number (space) First Name (space)
TTY response:	Student's last name
Student types:	Space Bar

TTY response:	Time	Date	TTY number
	Program begins		
Student types:	Letters and/or words requested by audio		

CURRICULUM CONTROL CHARACTERS

ACTION	CONTROL CHARACTERS
End of answer	Space bar
Repeat audio request	RUBOUT key
Repeat item presentation	RUBOUT key
Erase	RUBOUT key

To sign off

The time limit for a class is specified by the teacher. To sign off before program time limit,

Type: CTRL key and Z

Letters and numbers at the end of the printout refer to:

Strand	Letters L	Words W	Spelling SP	Phonics PH	Comprehension Categ.	Sent.
Section #	28	18	14	10	6	6

Refer to curriculum guide for specific curriculum items. For a report on student progress, see REPORT program.

W - BASIC

A CAI programming language geared to the junior high school student with a general mathematics background. Students must be enrolled for "W" program curriculum.

To sign on

Student:	Press the BREAK (START) key Press the Space Bar
TTY response:	HI PLEASE TYPE YOUR NUMBER AND NAME
Student types:	W Student Number (space) First Name (space)
TTY response:	Student's last name
Student types:	Space Bar

TTY response: Time Date TTY number
.

Student types: L (space) INST (RETURN)

TTY response: Copyright information

HELLO (student's name)

WHERE TO?

Student types: RETURN key to begin where previous lesson was terminated, or the letter and number of lesson, review or summary desired and the RETURN key.
Example: L1 means Lesson 1
R6 means Review 6
S9 means Summary 9

Lessons 1 through 50 are available.
Reviews exist for some lessons.

CURRICULUM CONTROL CHARACTERS

ACTION	CONTROL CHARACTERS
End of answer	Type RETURN key
Hint	Type Question Mark (shift key and ?)
Tell the answer	Type CTRL key and G
Skip this exercise	Type CTRL key and H
Go to choice point	Type CTRL key and J
Erase single characters (spaces are characters)	Type RUBOUT key
Erase entire line	Type CTRL key and U
Repeat problem	Type CTRL key and A

To sign off

The student may sign off the BASIC program at any time.

Student types: CTRL key and C

TTY response: .

Student types: K (RETURN)

TTY response: Sign-off message

Student manuals and homework assignments are available for the BASIC course from your Stanford representative. For daily report of student progress, see REPORT program.

Q - AID

A CAI programming language requiring a working knowledge of algebra. Students must be enrolled for "Q" program curriculum.

To sign on

Student:	Press the BREAK (START) key Press the Space Bar
TTY response:	HI PLEASE TYPE YOUR NUMBER AND NAME
Student types:	Q Student Number (space) First Name (space)
TTY response:	Student's last name
Student types:	Space Bar
IF TTY responds:	PASSWORD:
Student types:	AID (this will not print) RETURN key
TTY response:	Time Date TTY number .
Student types:	L (space) INST (RETURN key)
TTY response:	Copyright information HELLO (student's name) WHERE TO?
Student types:	RETURN key, to begin where previous lesson was terminated, or the lesson and number of lesson, review or summary desired and the RETURN key. Example: L1 means Lesson 1 R6 means Review 6 S9 means Summary 9 Lessons 1 through 50 are available. Reviews exist for some lessons.

CURRICULUM CONTROL CHARACTERS

ACTION	CONTROL CHARACTERS
End of answer	Type RETURN key
Request for hint	Type Question Mark (shift key and ?)
Tell the answer	Type CTRL key and T
Skip this exercise	Type CTRL key and H
Go to choice point	Type CTRL key and G

Erase single characters (spaces are characters)	Type RUBOUT key
Erase entire line	Type CTRL key and U
Repeat problem	Type CTRL key and A

To sign off

The student may sign off the AID program at any time.

Student types: CTRL key and C

TTY responses: .

Student types: K (RETURN)

TTY response: Sign-off message will begin

Student manuals are available for the AID course. Contact your Stanford representative. For daily report of student progress, see REPORT program.

E - BASIC ENGLISH

A CAI program dealing with problem areas of English grammar and usage designed for twelfth grade and beginning community-college students. It is particularly helpful for the bilingual student. This course, as developed by the Computer Curriculum Corporation of Palo Alto, is a self-instructional, self-paced program that can be used in conjunction with classroom curriculum. Students must be enrolled for "E" program curriculum.

To sign on

Student:	Press BREAK (START) key Press Space Bar
TTY response:	HI PLEASE TYPE YOUR NUMBER AND NAME
Student types:	E Student Number (space) First Name (space)
TTY response:	Student's last name
Student types:	Space Bar
TTY response:	Time Date TTY number Program will begin with introductory lesson, and thereafter, where previous lesson was terminated.

CURRICULUM CONTROL CHARACTERS

ACTION	CONTROL CHARACTERS
End of answer	Type RETURN key
Line erase	Type RUBOUT key

To sign off

A lesson, set for 45 minutes, may be terminated at any time by:

Typing: CTRL key and Z

For daily report of student progress, see REPORT program.

TALK PROGRAM

The 1971 version of the TALK program allows conversations between teletypes in the same terminal room as well as with those at other Stanford CAI locations. A directory of teletype numbers is available from your Stanford representative. Each CAI location is given the option of participating in the TALK circuit. Because our emphasis is upon curriculum programs, we encourage controlled use of the TALK program. However, where time schedules permit, and with the approval of the school administration, the TALK program provides a useful tool for learning and communication, particularly for the deaf students.

To sign on

Student:	Press BREAK (START) key Press Space Bar
TTY response:	HI PLEASE TYPE YOUR NUMBER AND NAME
Student types:	T Student Number (space) First Name (space)
TTY response:	Student's last name
Student types:	Space Bar
TTY response:	HELLO, (student name) YOUR TALK WILL BE RECORDED Conversations between teachers are not recorded. TYPE NUMBER YOU WANT:

Student types: (Number of teletype to be called) RETURN
or CTRL key and I (for instructions for
the TALK program)

The TALK program operates like a telephone.

1. Caller rings a number.
2. Phone rings.
3. Callee responds by typing any key.
4. The program reminds callee within 2 minutes to type CTRL and S, number and name if he wants to stay on the conversational circuit.
5. If there is no answer at the teletype caller requested, the program will print "no one answered."
6. A "busy" message will appear if teletype called is involved in a curriculum drill.
7. A "party-line" can be created by typing CTRL key and T, then typing the number of another teletype.
8. You may type GA (go ahead) and RETURN key to indicate completion of message.
9. CTRL key and Z sign any participant off.
10. If original caller types CTRL key and Z that TAIK circuit will terminate.

GUEST DEMONSTRATIONS

Guest numbers are available for most curriculum programs. These numbers are frequently reset for demonstration purposes. To initiate a demonstration in

MATH
STRANDS, type: S101 (space) GUEST (space) - refer to page 3.
S102 (space) GUEST (space)
S103 (space) GUEST (space)
S104 (space) GUEST (space)
S105 (space) GUEST (space)
S106 (space) GUEST (space)
also S111 through S116

The last digit of the number specifies grade level.

LOGIC, type: L111 (space) GUEST (space) - refer to page 4.
Problem #101.1 - start of first-year program
L112 (space) GUEST (space)
Problem #132.1 - truth-analysis problem
L113 (space) GUEST (space)
Problem #132.5 - counterexample mode
L114 (space) GUEST (space)
Problem #241.1 - multiple-choice story
L115 (space) GUEST (space)
Problem #215.16 - second-year derivations (algebra)
L116 (space) GUEST (space)
Problem #417.1 - algebra theorems, college curriculum

LANG. ARTS, type: G101 (space) GUEST (space) - refer to page 5.
or G111 (space) GUEST (space)

READING, type: R101 (space) GUEST (space) - refer to page 6.
also R102 through R106 and R111 through R116

Available only in schools with audio channels.

BASIC, type: W101 (space) GUEST (space) - refer to page 7.
or W111 (space) GUEST (space)

AID, type: Q101 (space) GUEST (space) - refer to page 9.
or Q111 (space) GUEST (space)

ENGLISH, type: E101 (space) GUEST (space) - refer to page 10.
E111 (space) GUEST (space)

REPORT PROGRAM

Daily Reports. Class reports should be available for teachers every day. Make time in your day to run them. Let the teletype work for you by utilizing the lunch hour, after school hours, or short periods between classes.

Become familiar with reports. Know how to read them and be prepared to interpret their contents for teachers. These reports contain helpful information to assist teachers in their effort to individualize instruction.

To sign on

Teacher:	Press BREAK (START) key Press Space Bar
TTY response:	HI PLEASE TYPE YOUR NUMBER AND NAME
Teacher types:	REPORT (space)
TTY response:	Time Date TTY number NEW CLASS REPORTER TYPE "?" FOR HELP AT ANY TIME CLASSES:
IF...you type	? (RETURN)
TTY response:	TYPE A LIST OF CLASSES LIKE THIS: 1,22-25,233 (RETURN) THIS WILL GET YOU CLASSES 1, 22, 23, 24, 25, and 233 CTRL-Z TO SIGN OFF 1, 22, 23, 24, 25, and 233 CLASSES:
Teacher types:	Desired CLASS NUMBERS (RETURN)
TTY response:	OPTIONS:
IF...you type:	? (RETURN)
TTY response:	TYPE ONE OR MORE OPTION LETTERS, THEN (RETURN) SPECIAL OPTIONS ARE ? FOR HELP CTRL Z TO GO BACK TO BEGINNING N FOR NAMES ONLY REGULAR OPTION LETTERS FOR REPORTS ARE A ALGEBRA D DENTAL HEALTH E BASIC ENGLISH G LANGUAGE ARTS L LOGIC Q AID R READING S STRANDS W BASIC X RUSSIAN

Teacher types:	Desired option letters from list above RETURN
TTY response:	NEAT PAGES? (TYPE Y OR N AND THEN RETURN)
IF...you type:	? (RETURN)
TTY response:	Y STANDARD LENGTH PAGES N PAGES ONLY AS LONG AS NECESSARY NEAT PAGES? (TYPE Y OR N AND THEN RETURN)
Teacher types:	Y or N for desired page size (RETURN)
TTY response:	OK

To sign off

The report program will terminate automatically or

Teacher types: CTRL key and Z

TTY response: GOOD-BY

Machine will turn itself off.

TROUBLE

Machines, like humans, have problems! When a teletype does not respond with the usual sign-on message or appears to be "hung up" in another program, try

1. CTRL Z (Press CTRL key and type Z)
   If this doesn't release the program,
2. CTRL C K RETURN (Press CTRL key and type C
   Type k..do not press CTRL
   Type RETURN key)
   If this doesn't release the program,
3. HELP RETURN (Type the word HELP and RETURN key)

One of these steps will usually work to return the teletype to student use. If you still have trouble, call Barbara Anderson on the phone for further assistance.

The Maintenance Handbook within this Handbook provides information to identify teletype or line problems, a check list of procedures to test operational equipment and flow charts depicting teletype troubles and possible corrections.

Local area schools....CALL 326-5261

Leave your name and name of school
Time of call
Problem TTY number
Brief description of problem

The problem will receive prompt attention from the CAI maintenance staff.

Out-of-state schools:

Each school will receive individual instructions at time of teletype installation.

OPERATION OF THE INSTRUCTIONAL TERMINAL

Care and Feeding of the Teletype Machine

This section is a handy reference for the minor, but important, operational aspects of the program, such as keeping the teletype machine supplied with paper and ribbon and the handling of minor stoppages. For detailed information on teletype or line problems refer to the Maintenance Handbook.

It is important that each proctor become thoroughly familiar with these practices. The efficiency of the whole program can be reduced significantly if the machine fails to operate and denies students regular daily lessons.

Most terminal stoppages occur for three reasons: paper threaded incorrectly, ribbon threaded improperly, and bits of paper wedged in the working parts.

Instructions for each of these items are given on the following pages. A picture of the teletype terminal is given in Figure 1.

INSERTING PAPER IN THE TELETYPE

1. Raise cover.
2. Move the PAPER RELEASE LEVER forward, lift the PAPER GUIDE, and pull the paper out from under the PLATEN. Lower the PAPER GUIDE.
3. Lower the cover.
4. Lift out the used roll.
5. Remove the SPINDLE from the core of the used roll; insert it in the new roll; place the new roll in position with the paper feeding out from underneath the roll toward the PLATEN.
6. Raise cover.
7. Feed the paper over the PAPER STRAIGHTENER ROD, down under the PLATEN, lift the PAPER GUIDE, and feed the paper between the PLATEN and the PAPER GUIDE.
8. Pull paper up a few inches beyond top of PLATEN. Straighten the paper. Lower the PAPER GUIDE to rest on the paper. Move the PAPER RELEASE lever back.
9. Lower the cover, making sure that the end of the paper feeds out through the top of the cover.

Figure 2 shows the position of the paper when properly threaded.

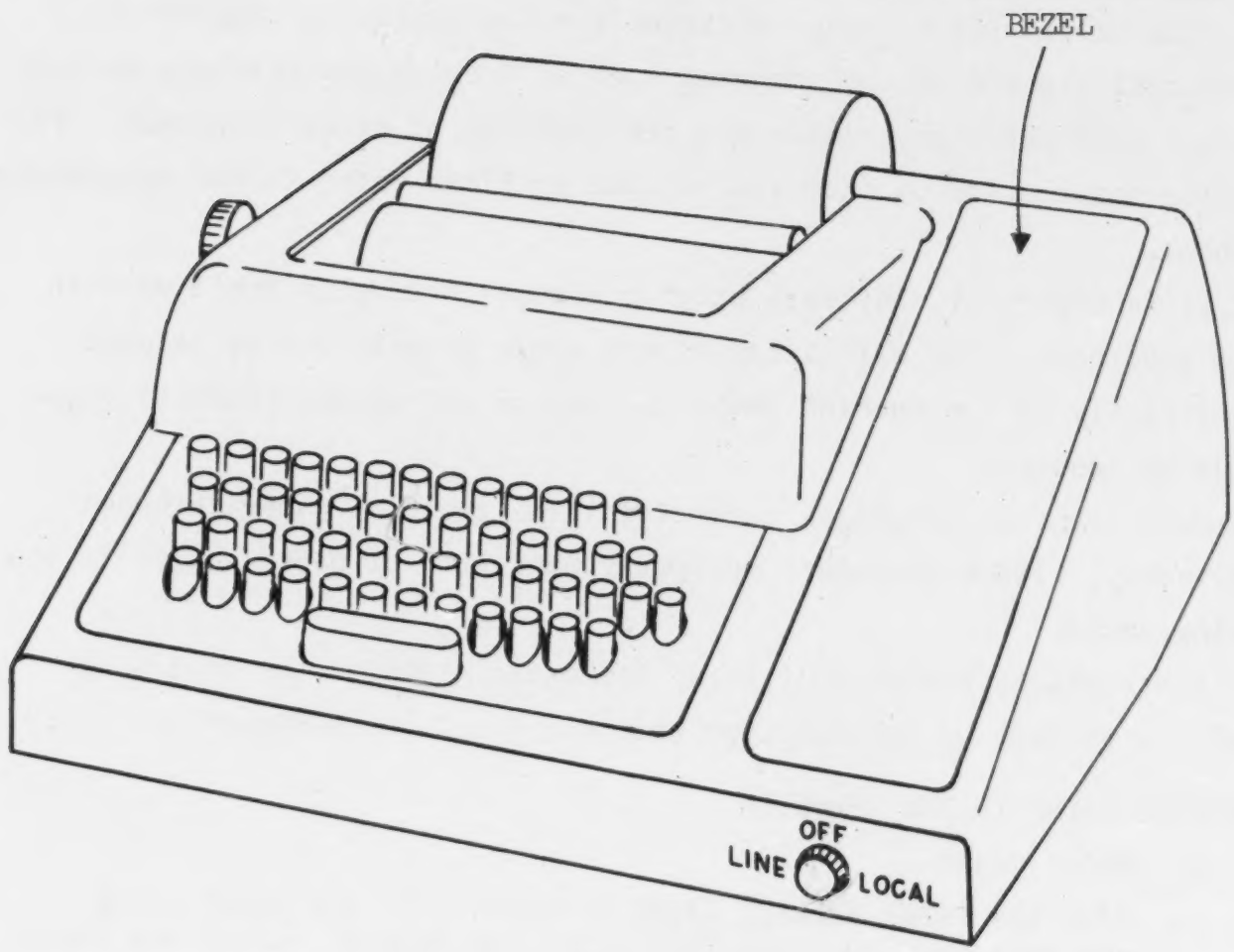

Fig. 1. A teletype terminal.

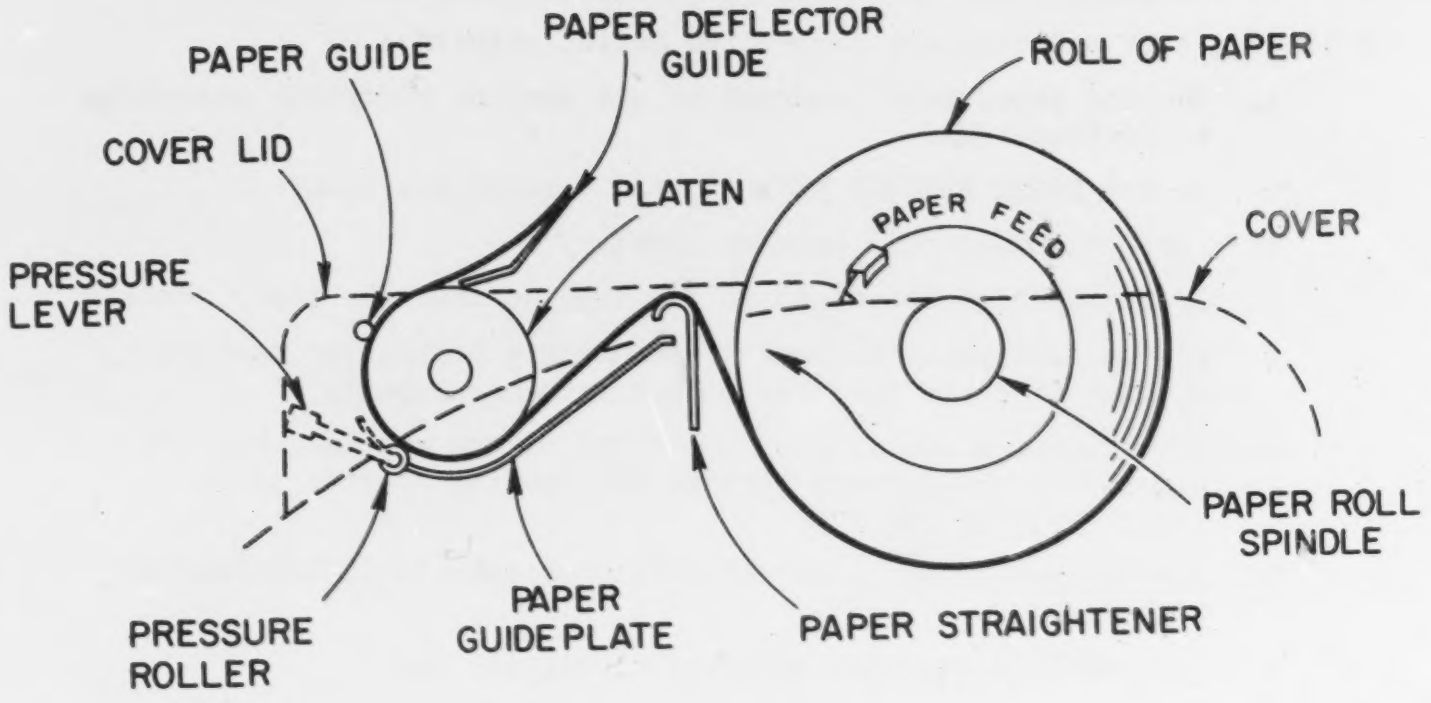

Fig. 2. Position of properly threaded paper.

PAPER FEED TROUBLES

If the paper feeds to one side, tears, or jams, etc., check the following list and take any corrective action required:

1. Has the paper been inserted in the machine correctly according to instructions?
2. Is the PAPER RELEASE LEVER in the correct position?
3. Does the paper roll revolve freely?
4. Is the machine too close to the wall so that the paper jams?
5. Is too much paper allowed to accumulate behind the machine so that it can't feed out of the machine properly?
6. After opening and closing the cover of the machine, has the paper been brought out through the opening so that it is feeding out at the top?
7. Has the paper been torn off evenly so that it is feeding out properly?

If the trouble continues, notify your service man.

CHANGING THE TELETYPE RIBBON

Use a standard teletype ribbon. Check the box for the word "teletype" or "teletypewriter." This type of ribbon is similar to a typewriter ribbon, but it is made especially for teletypes. It is one-half-inch wide, has a reversing eyelet at each end of the ribbon and is on a spool that fits the teletype-ribbon spool shaft.

Check the condition of the ribbon frequently and replace it as soon as it becomes worn; otherwise, it may produce illegible copy or cause service interruptions. The position of the ribbon when correctly threaded is shown in Figure 3.

HOW TO CHANGE RIBBON

1. Raise cover.
2. Remove both SPOOLS from the RIBBON SPOOL SHAFTS.
3. Release the RIBBON from the RIBBON REVERSE LEVERS and RIBBON GUIDES.
4. Unwind and remove the old ribbon from one of the SPOOLS.

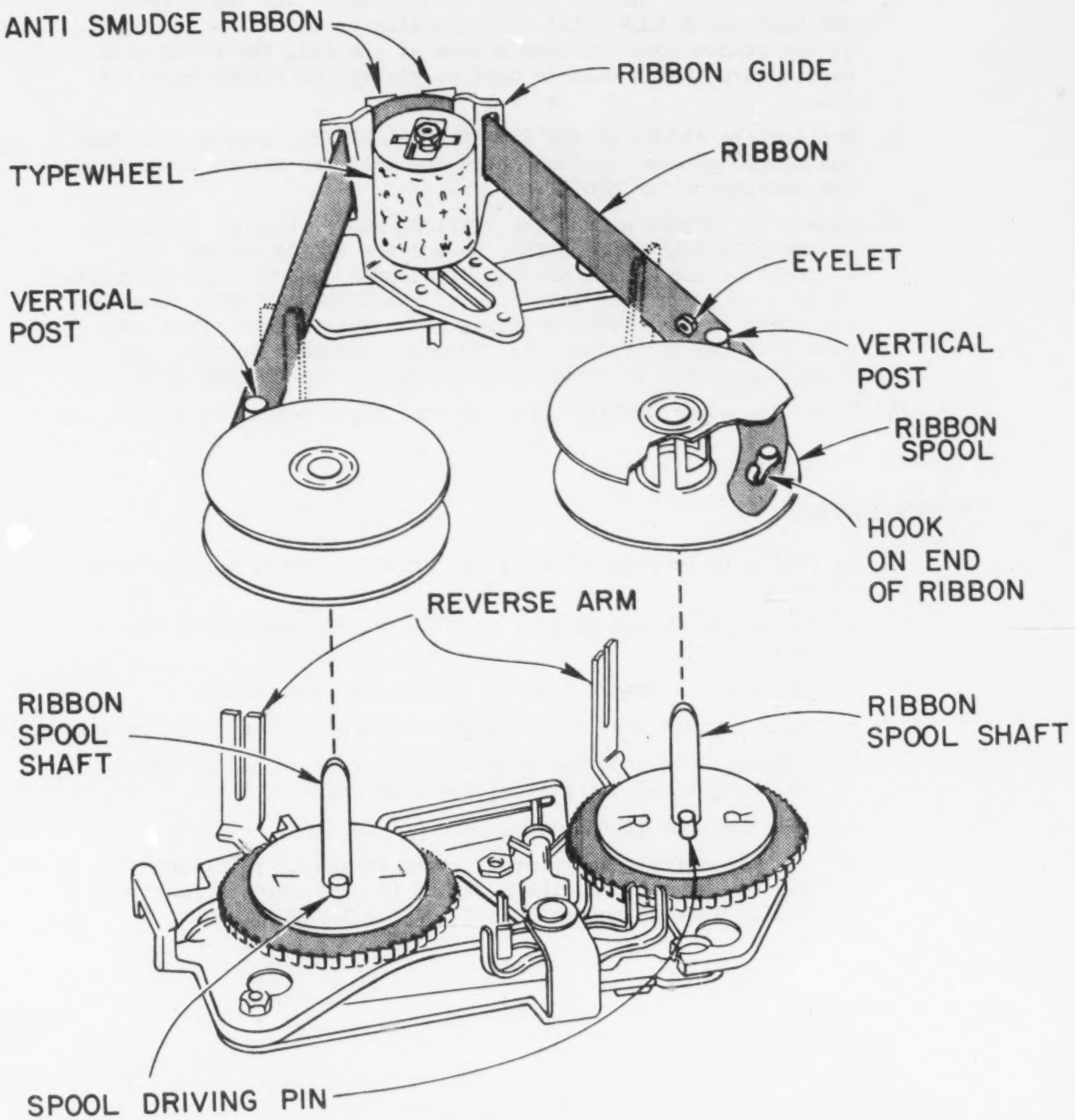

Fig. 3. Ribbon threading

5. Hook the end of the new ribbon to the hub of the empty spool and wind the RIBBON until the reversing eyelet is on the SPOOL. If the ribbon does not have a hook at the end, the SPOOL will have a barb that should be used to pierce the RIBBON near its end.

6. Replace the SPOOLS on the RIBBON SPOOL SHAFTS, making sure that the SPOOLS go down on the shafts and that the ribbon feeds from the outside of the SPOOLS.

7. Thread the RIBBON around the VERTICAL POSTS, through the slots in the RIBBON REVERSE LEVERS, around the RIBBON GUIDES, and in front of the smudge shield if equipped, and through the slots on both the right and left side of the RIBBON GUIDES. Take up the slack in the RIBBON by turning the free SPOOL. Then make sure that the ribbon is still properly threaded so that the reversing eyelet is between the SPOOL and the REVERSE LEVER.

8. Lower the cover, making sure that the paper feeds out at the top.

RIBBON TROUBLES

1. If ribbon is feeding properly but print is faint, a new ribbon is needed.

2. If the ribbon is not feeding or fails to reverse, check the following list:

   a. Be sure a standard teletype ribbon has been used.

   b. Make certain that it has been put on according to instructions.

   c. Check to see that the ribbon is not worn so badly that it has caught on some part of the teletype.

   d. See that the ribbon spools are not damaged.

   e. If ribbon fails to reverse, check to see if reversing eyelet is still on ribbon, if it is make sure it is correctly located between spool and the REVERSE LEVER.

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2.	Trouble Diagnosis by the Teacher or Proctor	6
3.	Trouble-reporting Procedures	18
4.	Teletype Trouble	21

MAINTENANCE HANDBOOK

The communications network, together with the curriculums and the computer, is an essential part of the Stanford CAI programs.

Even though a well-planned program of preventive maintenance has been implemented for all electronics and mechanical equipment, breakdowns will still occur. Some breakdowns are minor and can be corrected by the CAI classroom proctor. Other failures that cannot be repaired by the teacher may be diagnosed or described to a repairman, thus restoring use of the terminal with the least possible delay.

The purpose of this Handbook is to inform the teacher and the proctor of the various elements that comprise the communications network and what she may do to insure continuity of operation.

1. The Communications Network

This section explains how signals are carried from the Stanford computer to a school and the capabilities of the student terminal.

The Stanford CAI communication network supports nearly 200 terminals, ranging from Model-33 teletypewriters operating at 100 words per minute to sophisticated high-speed cathode-ray tube devices operating at 10,000 words per minute. Classrooms, located on the Stanford campus and as far away as Washington, D.C., are all connected by telephone lines that are either leased from the telephone company or owned by Stanford University.

Transmission media. Four basic methods are used to transmit signals between the computer center and a school. The one selected depends on the distance and/or number of terminals at the school.

a. Direct wire (i.e., private cable).[1] This method is suitable for locations up to 1-1/2 miles from Stanford. A pair of wires for each terminal is run from the computer center to the school, and a signal[2] is transmitted over the wire from Stanford to the school teletype. No other electronics is involved. See Figure 1.

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[1] Stanford uses the same cable that is used by the telephone company. The cables are made of pairs of wires, or two wires twisted together. Thus, a 25-pair cable contains 50 wires.

[2] As used in this context, 'signal' means computer information converted to electrical energy.

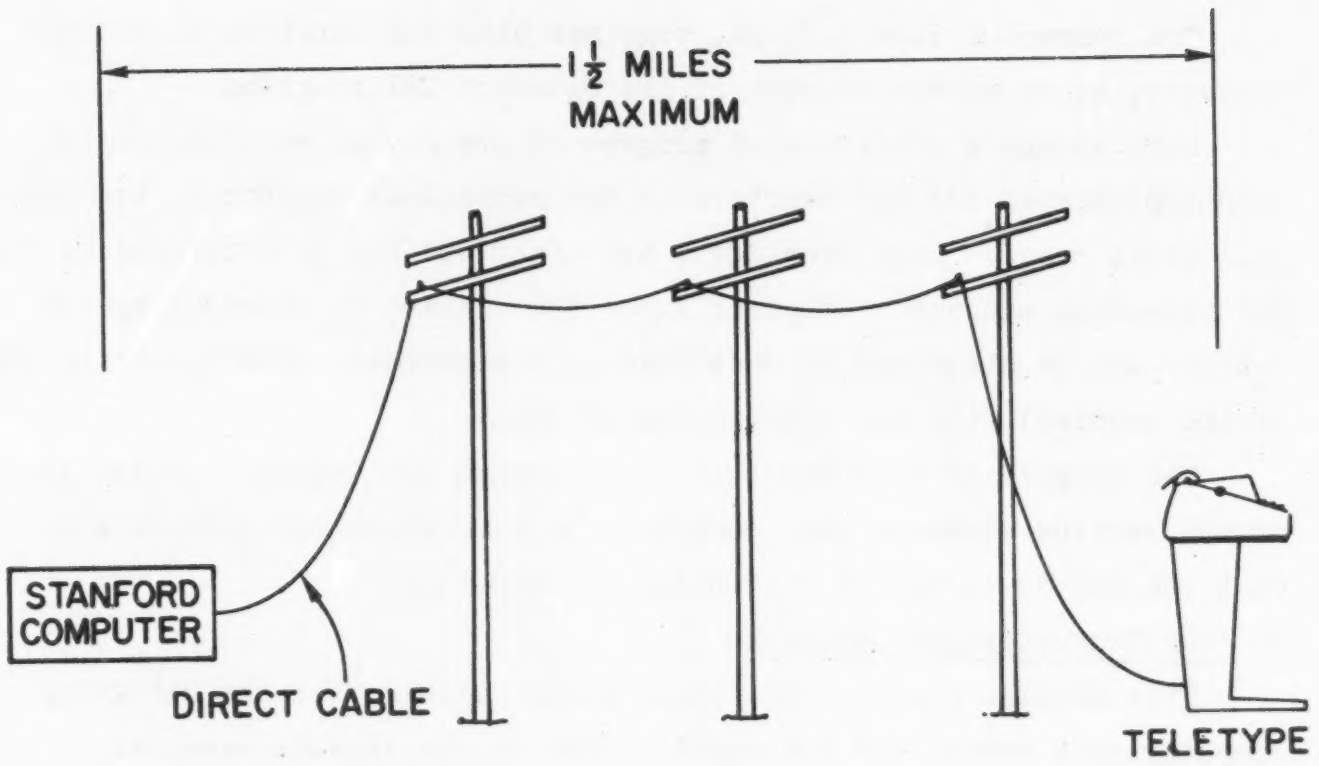

Fig. 1. Direct wire transmissions of signals.

b. Frequency division multiplexing[3] (FDM). In Stanford's program the FDM method sends tones or sounds of different frequency over a voice-grade private telephone line. With a set of tones for each teletype channel, as many as 17 different teletype channels can be carried over a single line. All of them can be mixed together at the sending end and filtered or separated at the receiving end. This equipment is known as "Collins" data sets. Distances involved are anything greater than 1-1/2 miles. See Figure 2.

c. Time division multiplexing (TDM). As many as 64 teletype channels can be carried over a single voice-grade telephone line, which is a line rented from the telephone company for sole use by IMSSS. A small computer located at the terminal end of the telephone line receives information from the telephone line in serial form at a rate of 2400 or 4800 bits per second (pieces of information per second). This information is transmitted from Stanford in sequential order so that the first 8 bits are for channel A, the next 8 bits for channel B, etc. The computer sorts this information and retransmits it, at a slower rate, to the individual teletype channels. See Figure 3.

d. Dial-up data phone. This service is available for occasional users of the system. The user dials a specified telephone number at Stanford from any telephone at his location. The call is automatically answered by the computer. The user then places the telephone receiver in a portable data set[4] or an "acoustic coupler." Only one teletype channel may be used over any one dial-up line. For all of the above connections to the

---

[3] Multiplexing is defined as many information channels sharing the same circuit, or in our application, many teletype channels sharing the same telephone circuit.

[4] A data set allows machines to talk over ordinary telephone lines by converting the machine's signals into audio tones.

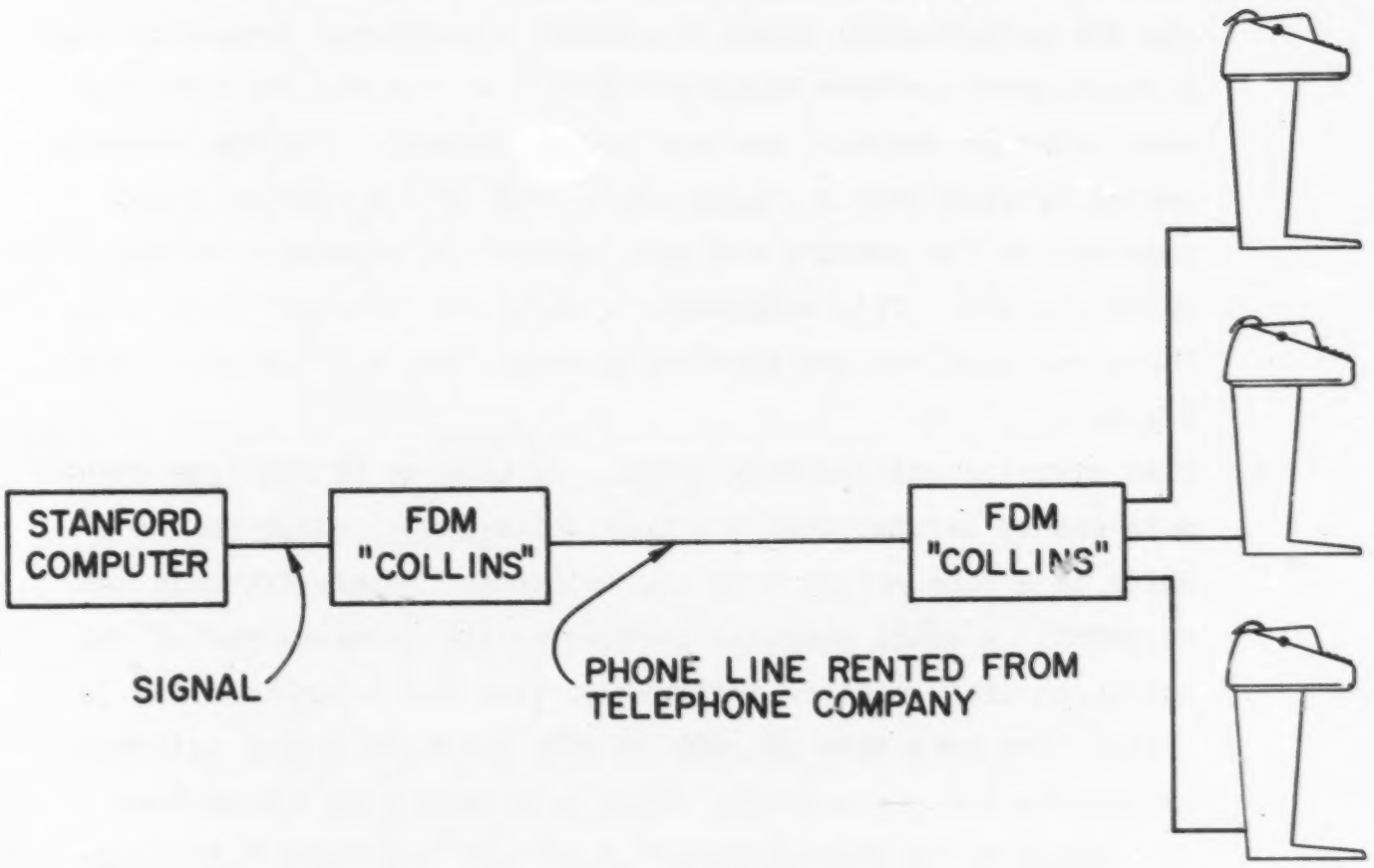

Fig. 2. Transmitting tones or sounds over telephone line over distances greater than 1-1/2 miles.

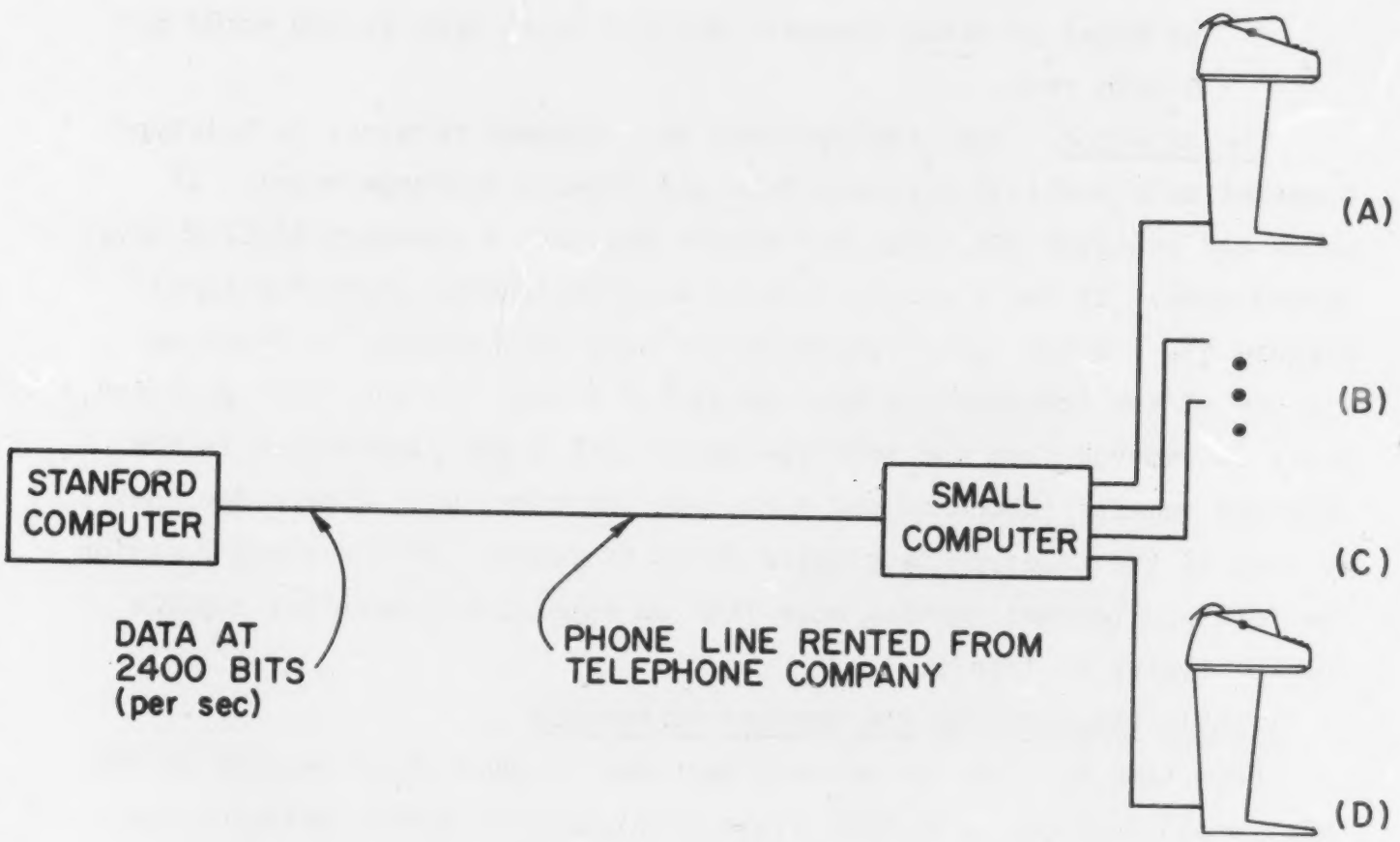

Fig. 3. Flow of bits from Stanford computer to channels.

Stanford CAI system the teletype must be a teletype Model 33 or Model 35 using standard ASCII 8 level code at 100 words per minute rate.

The teletype. The teletype used as a student terminal is Teletype Corporation's Model-33 Keyboard Send and Receive Teletypewriter. It sends and receives 100 words per minute and uses a standard ASCII 8 level serial code. It has a single control knob designated "Line-Off-Local" (Figure 4). In the "line" position the unit is connected to Stanford via one of the transmission methods listed above. In the "off" position, power is removed from the teletype motor only. The electronics in the teletype remains turned on and therefore the cover will always feel hot as long as the teletype is plugged in to AC power. In the local position, the teletype becomes nothing more than an expensive typewriter capable only of typing to itself.

2. Trouble Diagnosis by the Teacher or Proctor

From time to time the proctor may have to make minor repairs on the teletypes. Some problems that occur from paper or ribbon malfunctions are covered in the Proctor's Handbook in this manual. This section outlines the procedures that may be used to analyze and repair minor troubles.

Teletype troubles. Some of the more common problems that a proctor can diagnose and correct are discussed below. The proctor should take immediate action when trouble occurs, and if she is unable to correct it, she should notify the CAI laboratory as soon as possible. Individual out-of-state schools receive repair instructions at time of teletype installation.

A. Machine does not line feed or paper feed.

.... Is paper installed correctly?

√ Check diagram showing paper installation (Figure 2, Proctor's Handbook).

.... Is paper-release lever in up position?

√ Flip release down toward you.

.... Is paper roll rubbing or obstructed?

√ Check for ease of clearance.

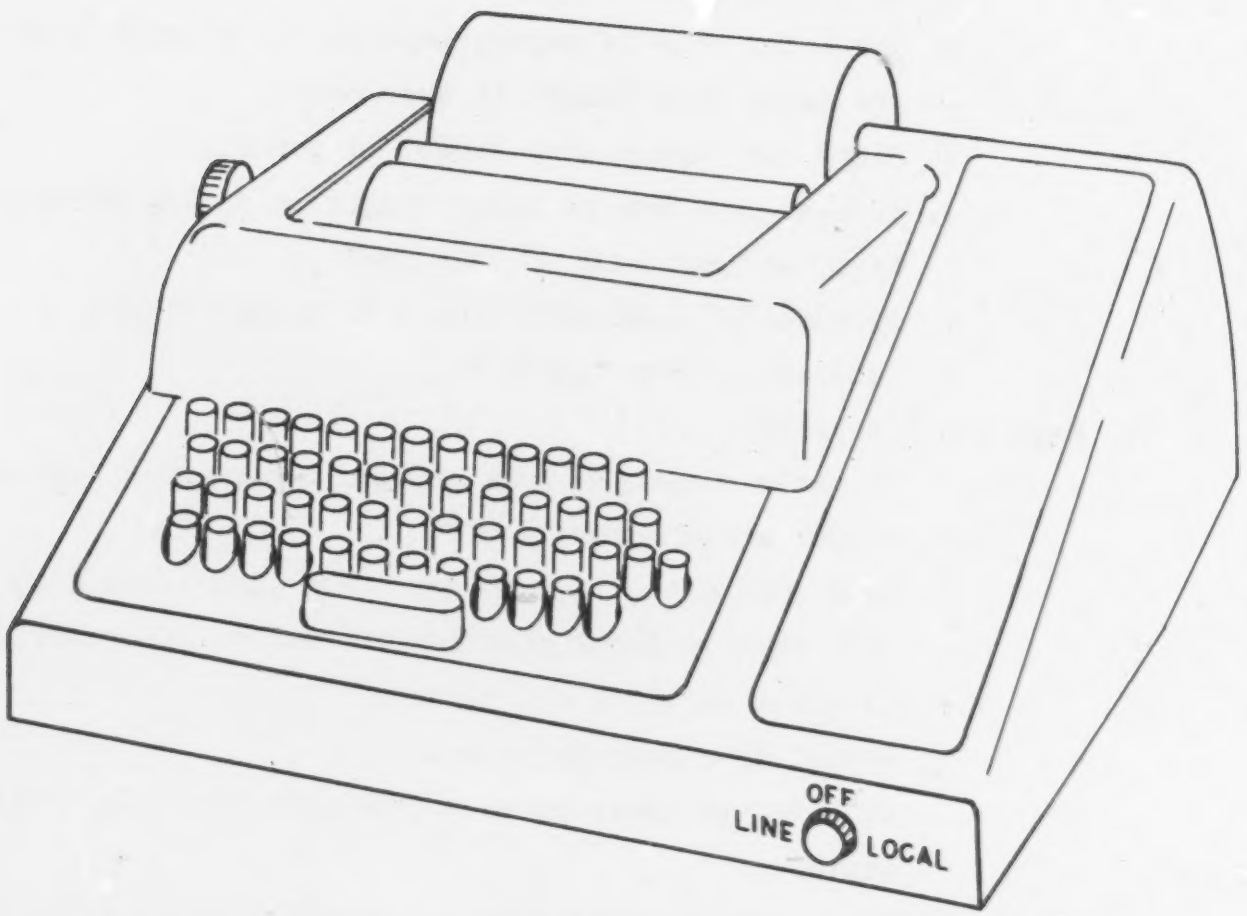

Fig. 4. Position of line-off-local control knob.

B. Carriage fails to return or space.

.... Is carriage obstructed?

√ Check for bits of paper, pencils, or foreign objects.

.... Are paper bits caught in dash pot?

√ Clean out scraps with finger or pencil.

.... Is L-shaped hook on belt, caught on spring-extension lever on left side of teletype?

√ Release "L" hook with finger to permit return of carriage. (See Figure 5.)

C. Keys won't depress.

.... Is motor running? This problem occurs when keys are struck while motor is off.

√ Make sure motor is running. Turn line-local knob to off, then to local position to test as typewriter.

.... If motor still is not running,

√ Report to repair personnel.

.... If teletype operates as a typewriter but keys won't depress,

√ Lift plastic cover shield. Locate H-lever plate in right corner inside teletype. With eraser end of pencil press downward on right-hand side of H lever (see Figure 6). You should hear a "click," which resets the keyboard for normal operation. You may have to repeat this procedure. Test teletype in "local" then, return line-local knob to line.

D. Teletype receives garbled characters.

The following tests will determine if garbled characters are coming from:

1. Teletype
2. Interface unit between line and teletype
3. Telephone line

Test 1: Turn line-local knob to "local." Type a line of characters. If teletype is still typing garbled or incorrect characters:

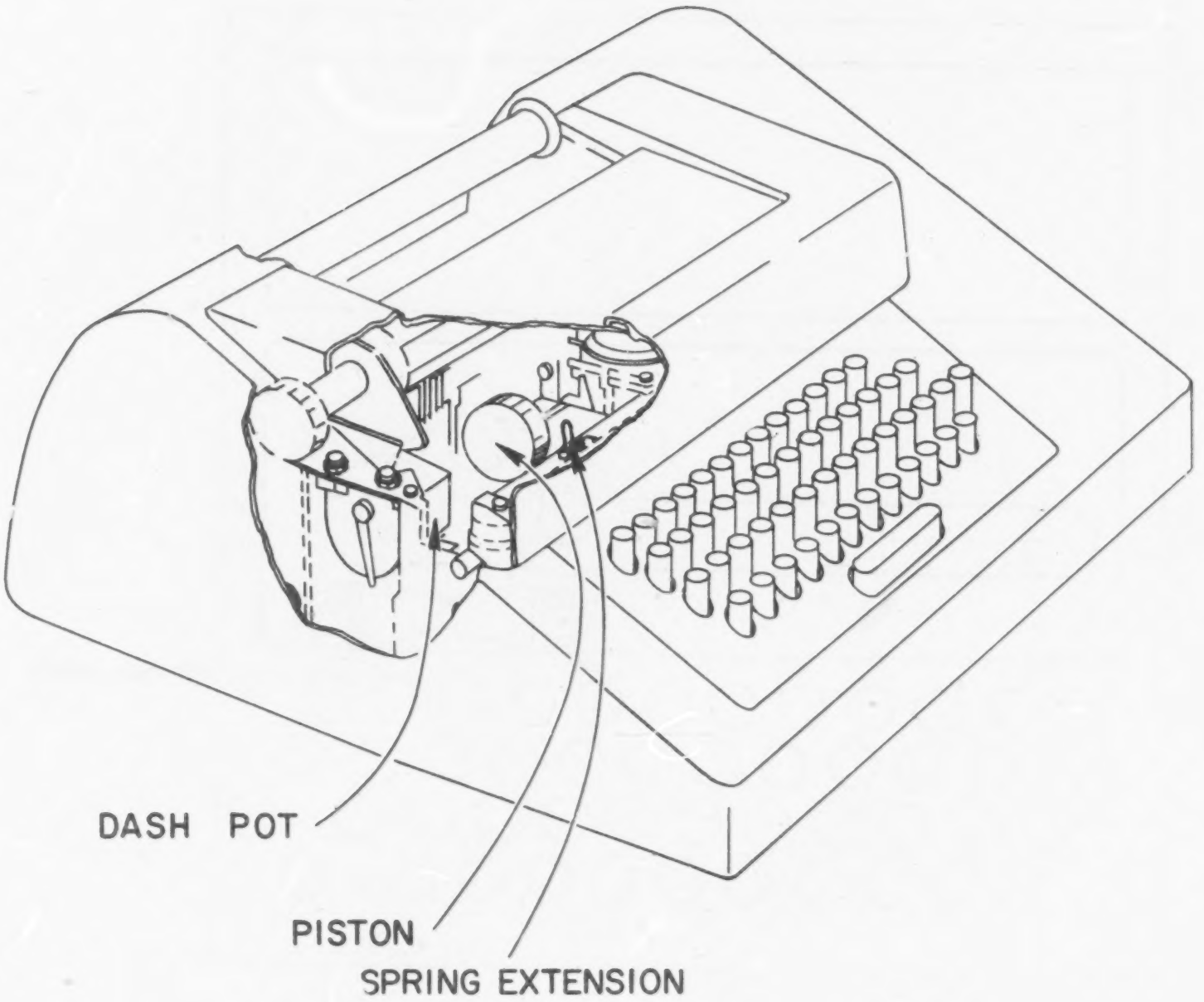

Fig. 5. Dash pot and spring-extension lever.

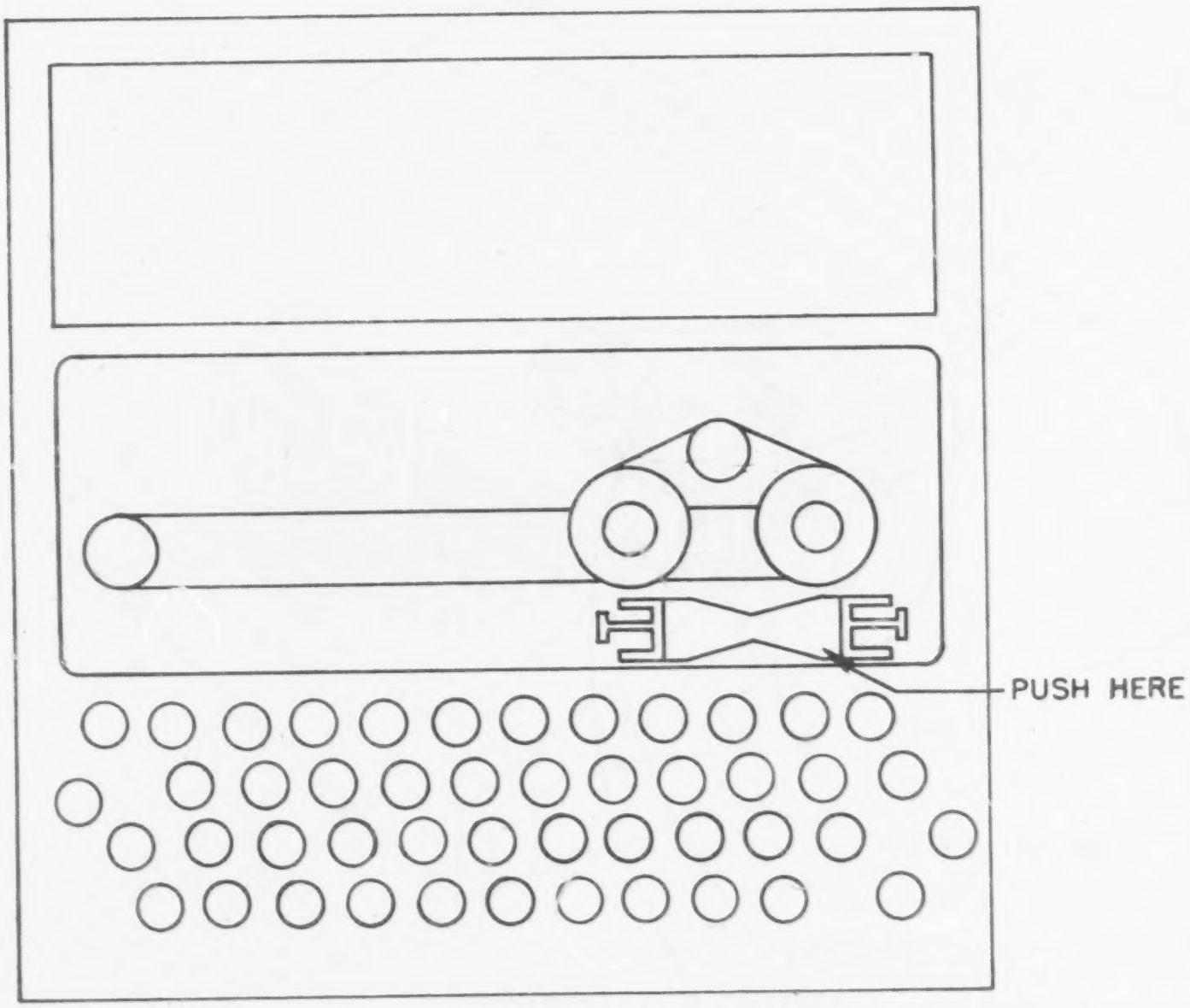

Fig. 6. H-lever plate.

USI 121

√ Report problem to repair personnel, mentioning test performed.

√ Replace terminal with spare teletype. This is a teletype problem.

If, after Test 1, the teletype types normally on local but characters are garbled on line, proceed to Test 2.

Test 2: Unplug the signal cord (see Figure 7) from the line plug and insert signal cord into red test plug. Restore line-local knob to line position. Press BREAK (START) key for 2 seconds and release. The motor should be running now. Type a line or two to test for garbled characters. If teletype fails to type correctly,

√ Report problem to repair personnel and mention tests performed.

√ Replace terminal with spare teletype.

√ This is a teletype problem.

If teletype types correctly, remove the red plug and connect the signal cord back to the signal-line plug. If teletype is still typing garbage characters, refer to section on troubles in the Proctor's Handbook, page 15.

Refer to flow chart on page 22. When reporting defective teletypes, mention tests you have performed.

E. Motor fails to turn on.

.... Is teletype plugged into wall outlet?

√ Check for secure connection.

.... Does teletype operate in local mode?

If yes, but motor does not run in line mode, remove back panel (Figure 8) and locate bypass switch (Figure 9) on the motor control timer and move switch to bypass. Return line-local knob to line. If teletype operates in this mode, leave bypass switch operating and report the motor failure and bypass correction to repair personnel.

.... If teletype did not turn on in local,

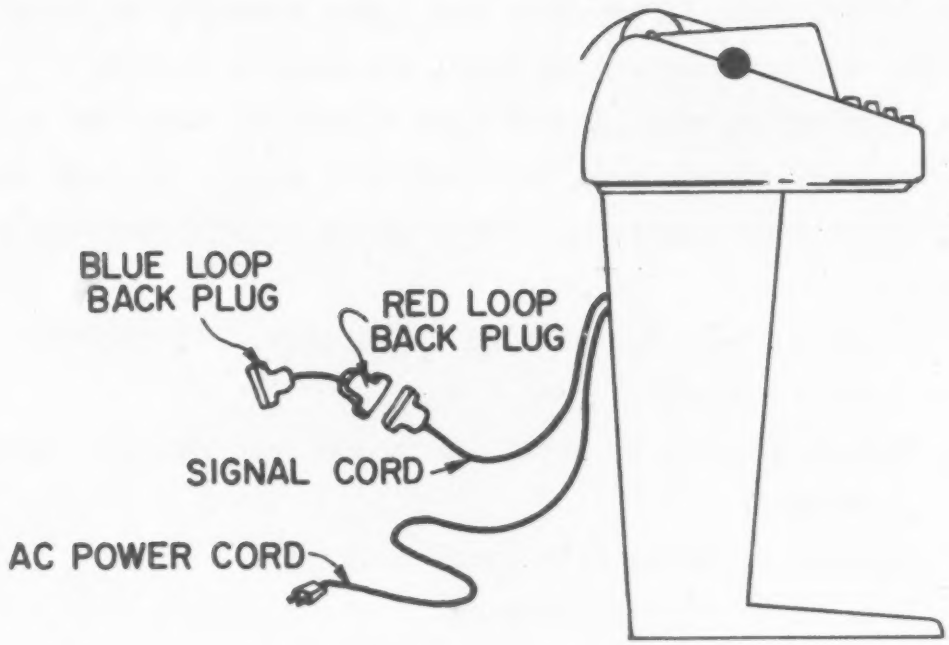

Fig. 7. Positions of red loop back plug and signal cord.

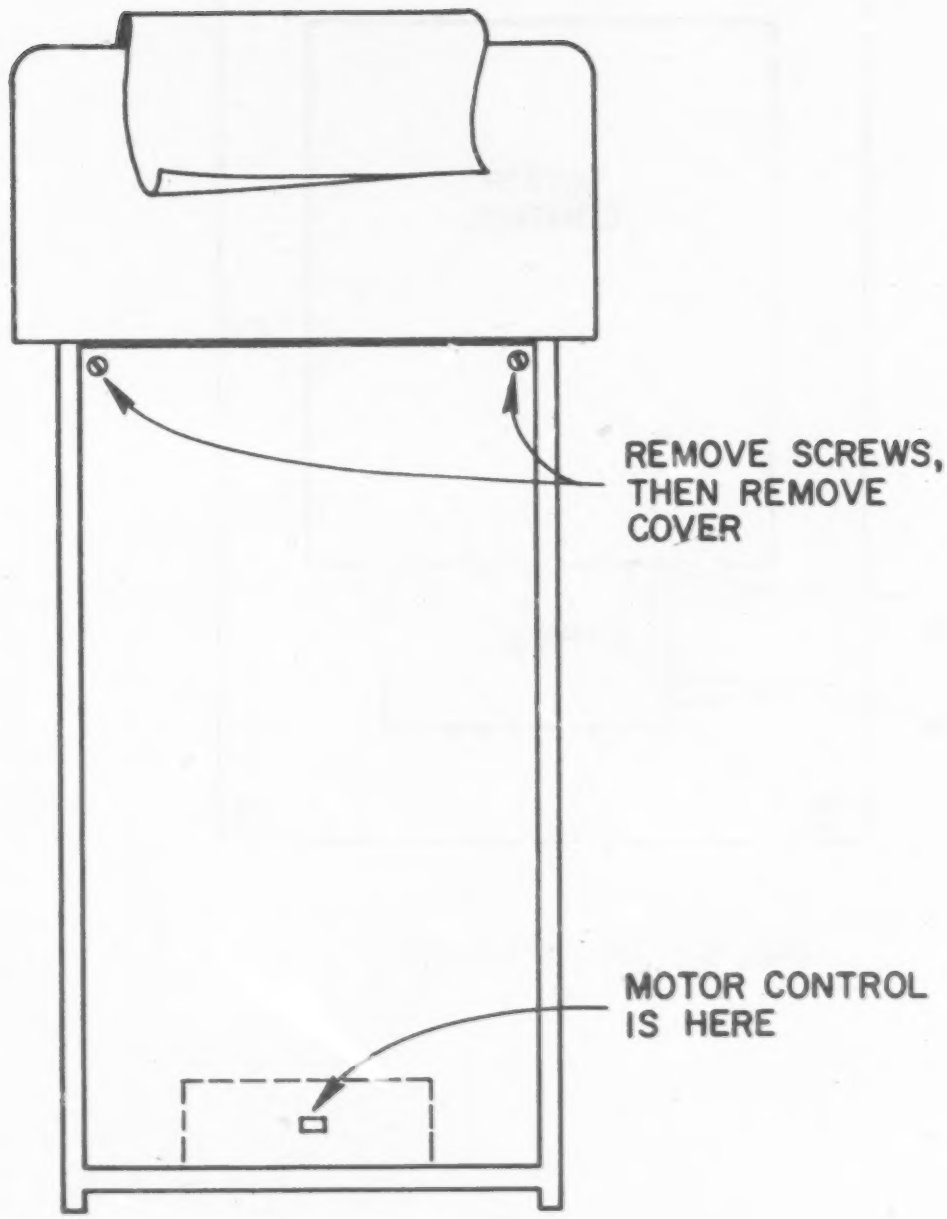

Fig. 8. Back panel of teletype.

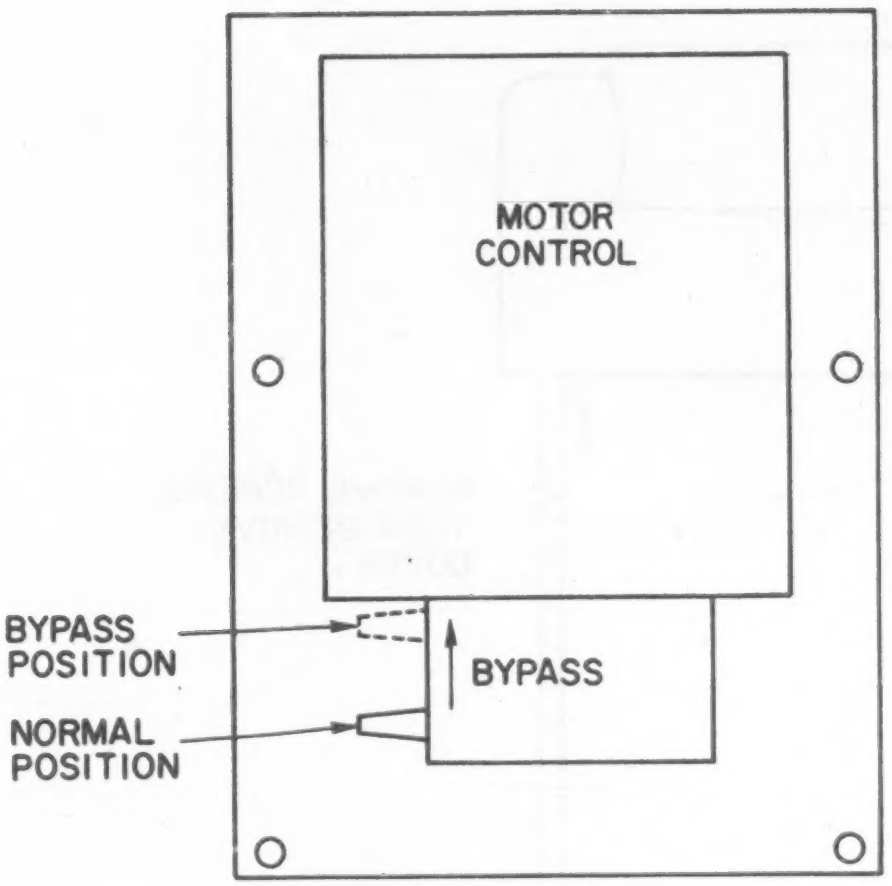

Fig. 9. Bypass switch.

√ Check wall outlet by plugging in another teletype, if you have more than one, or test with any electrical device such as a lamp or radio.

.... Do you suspect wall outlet?

√ Clear this problem with your school office.

.... Do you suspect a blown fuse (Figure 10)?

√ Replace defective fuses with correct (rating) fuse. Be sure to pull the AC power plug when checking fuses. If motor still does not operate or fuse blows again,

√ Report to repair personnel and mention procedures tried.

√ Replace teletype with a spare if you have one. Refer to flow chart on page 23.

F. Bent keys. Often a student will press so hard on the start, shift or CTRL key that he will bend it and cause it to stick. Students should be instructed not to pound keys or exert heavy pressure on keyboard.

.... If the key is bent,

√ Work key back up to normal position.

√ Place thumb on the forward vertical surface of the key (Figure 11) and apply gentle pressure, back and up.

.... Check for freeness of operation.

√ Repeat above process using slightly more pressure each time until key operates freely.

√ Caution: Too much pressure will make key stick permanently, requiring a service man.

Telephone line troubles. Telephone line troubles are a source of irritation because they appear as teletype problems, and the proctor can do little to correct them. After applying the tests in step D in Section 1 of teletype problems and after verifying that the terminal is functioning properly, check the following points.

.... Is there more than one teletype at the location?

√ Determine whether other machines are also in trouble.

√ If yes, notify Stanford that you suspect line trouble on all of your teletypes.

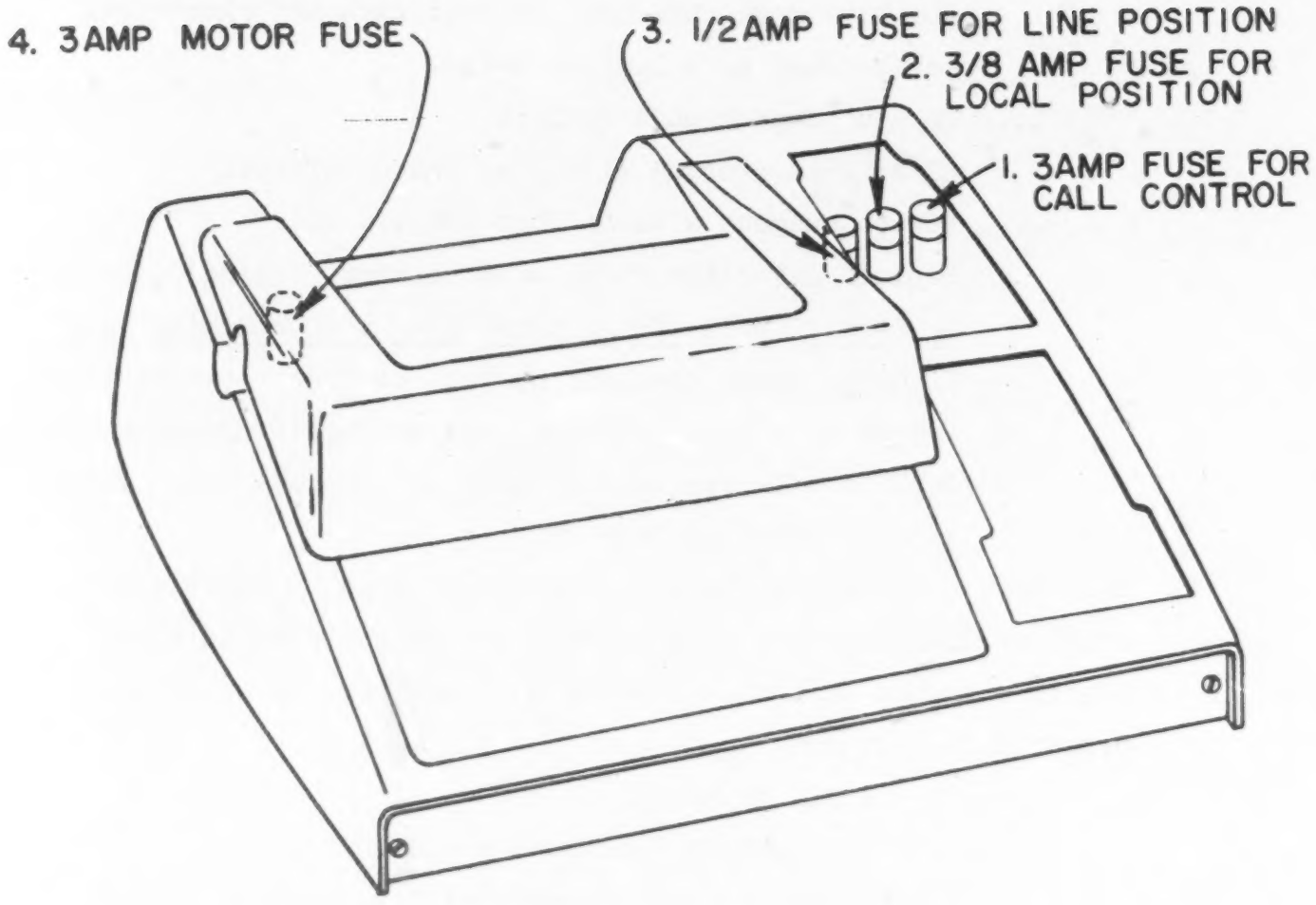

Fig. 10. Locations of fuses.

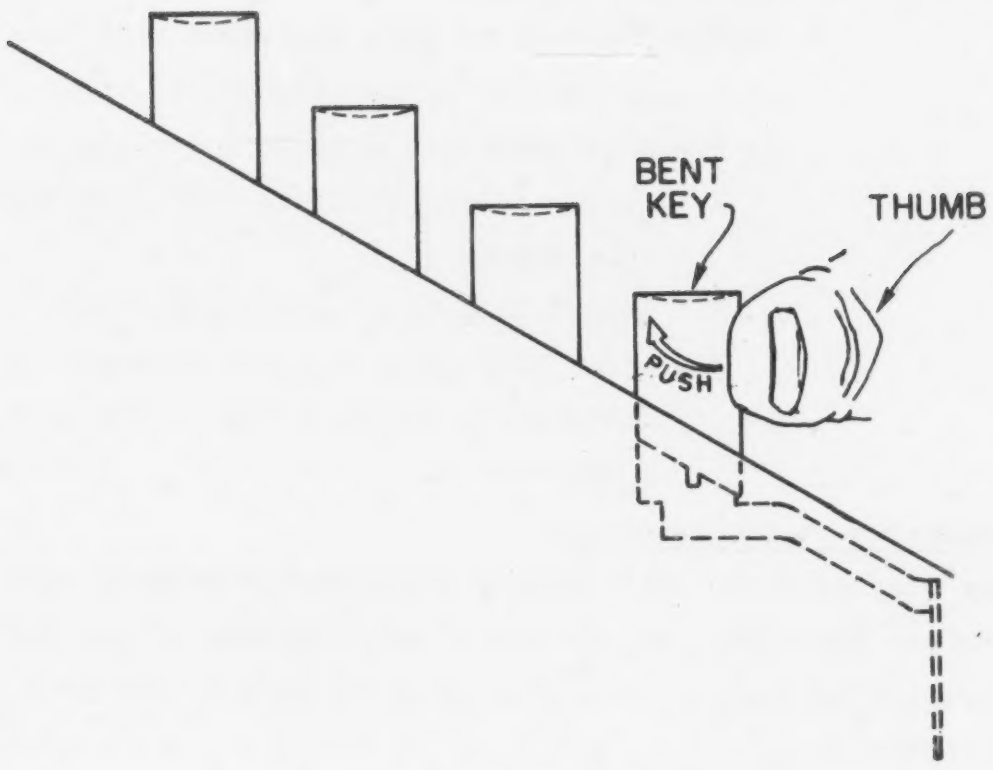

Fig. 11. Straightening bent key.

.... Is the problem one (or more, but not all) of your teletypes?

√ Check the teletype.

√ Advise Stanford of your tests and tell them you suspect line trouble on one channel(s) only.

.... If Stanford wishes to perform loop-back tests,

1. Unplug teletype signal cord from signal line. (See Figure 12.)
2. Insert blue plug into signal line.
3. Leave blue plug inserted in signal line until notified by Stanford that tests have been completed.

3. Trouble-reporting Procedures

This chapter deals with trouble-reporting procedures within the San Francisco Bay area. If you are located outside of the Bay area, special reporting instructions will be given to you when your Center becomes operational.

Operational difficulties (not related to machine failures). For assistance with programs, student number changes, etc., call the IMSSS computer operator directly at (415) 321-2300, Ext. 3137 or (415) 326-5261.

For equipment repair service, call (415) 326-5261 and give the following information:

a. your name
b. name of your school
c. date and time
d. teletype number or channel
e. nature of trouble and tests performed.

Service will usually be provided the same day for users in the San Francisco Bay area if calls are in by 8:30 A.M. Because of the geographical spread of our equipment and the complex nature of computing equipment, we cannot guarantee the exact hour a call will be serviced or the reported trouble fixed.

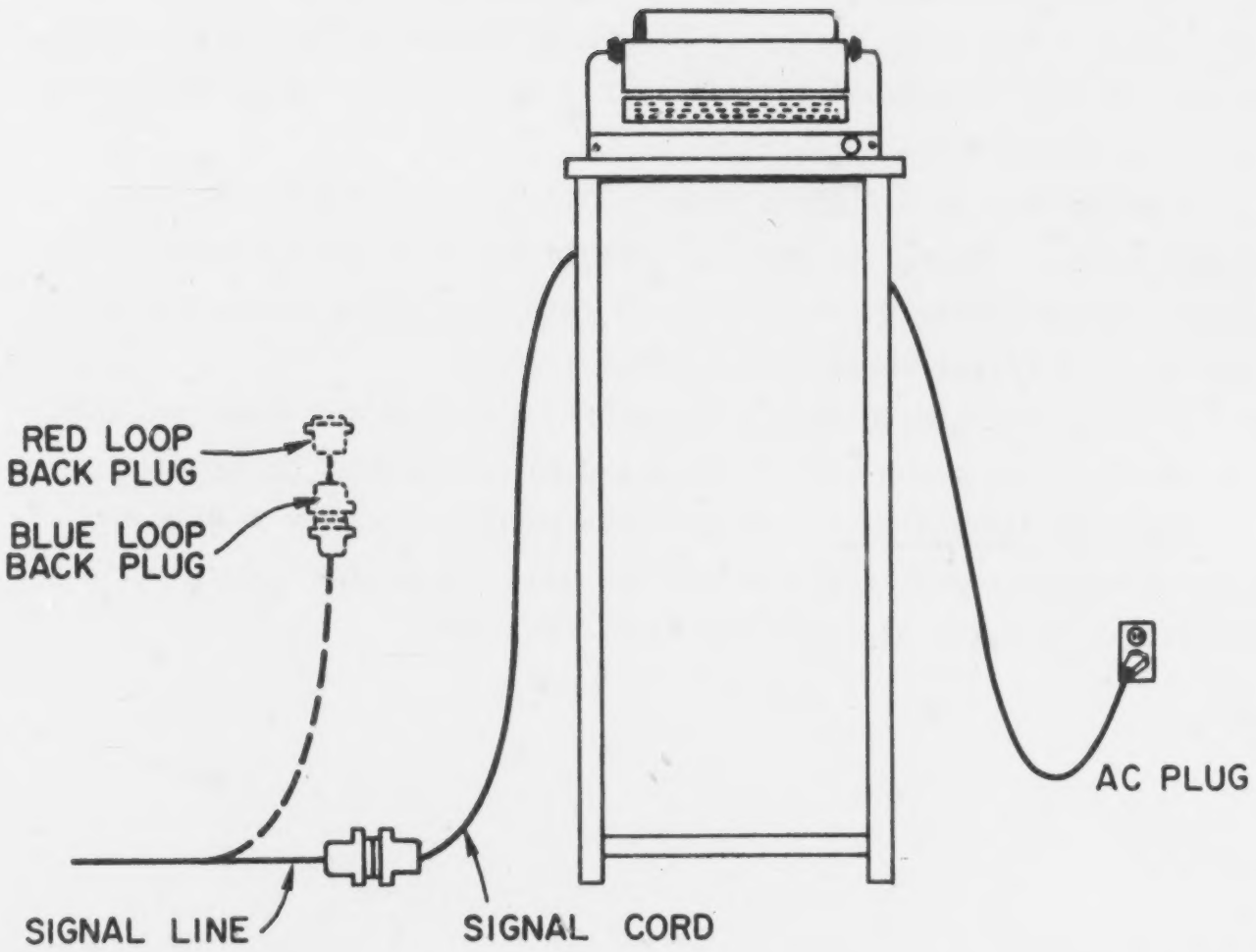

Fig. 12. Positions of red loop and blue loop plugs.

Access to the equipment. When any piece of CAI equipment (device) has been reported as being out of order, it is expected that the serviceman will have access to the equipment when he arrives at the school. When equipment is being tested at Stanford, the serviceman will control the use of that device and release it for service when he is satisfied that it is functioning correctly.

A serviceman is available from 8:30 A.M. to 5:30 P.M., Monday through Friday. Except by special arrangement with the manager of the computer-based laboratory, all service work, including preventive maintenance, will be performed within these times.

In order to service faulty equipment, the Stanford repairmen must have access or be given keys to building by maintenance personnel.

Repeated difficulties. If problems recur or you are unable to obtain adequate repair services, please call the manager, computer-based laboratory, directly at (415) 321-2300, Ext. 4049.

4. Teletype Trouble

Paper feed and line feed trouble

1. Be sure paper is installed correctly.
2. Is anything binding or rubbing on paper roll?
3. Is the paper release lever in the "up" position?

Carriage doesn't return or sticks

Check for obstructions such as bits of paper, pencils, and other foreign materials.

Check L-shaped hook on belt for spring-lever obstruction

Keyboard keys won't push down

Is machine on?

Apply pressure to the "H" lever with the erasure end of a pencil.

Stuck start, CTRL, or shift key

Work key back to normal position, using your thumb to apply pressure back and up to straighten key.

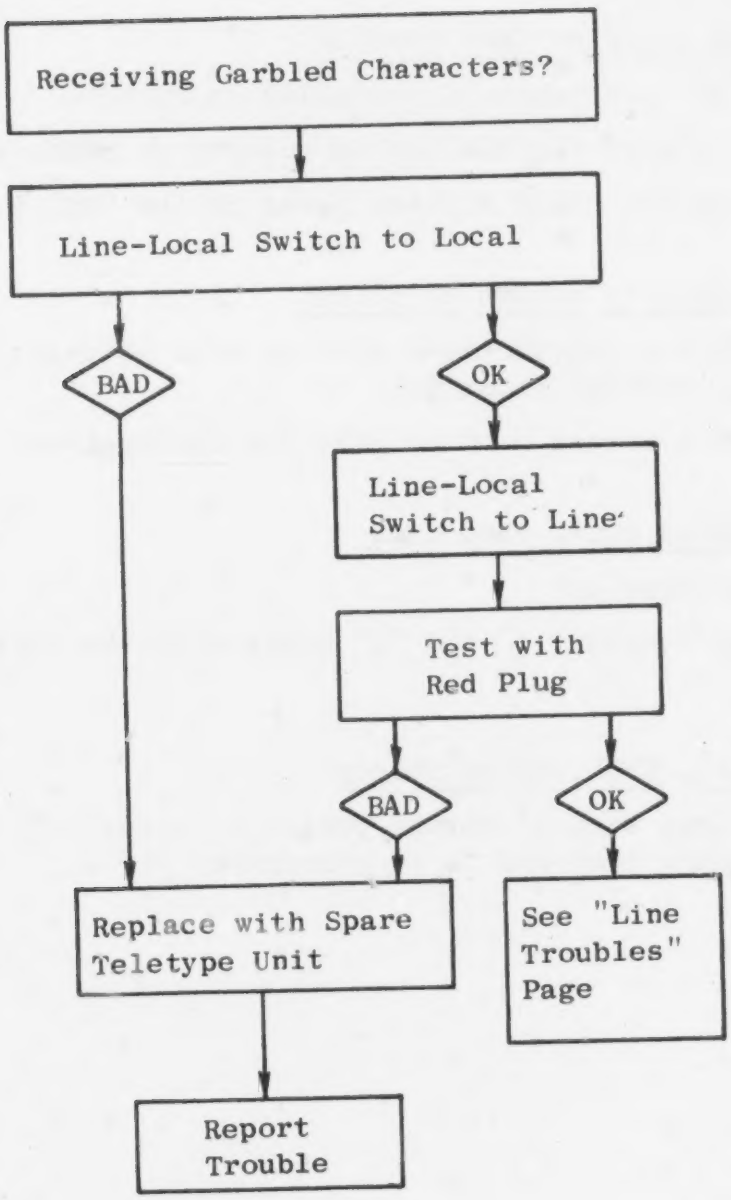

Fig. 13. Test for garbled characters. (Flow chart for check list on page 11.)

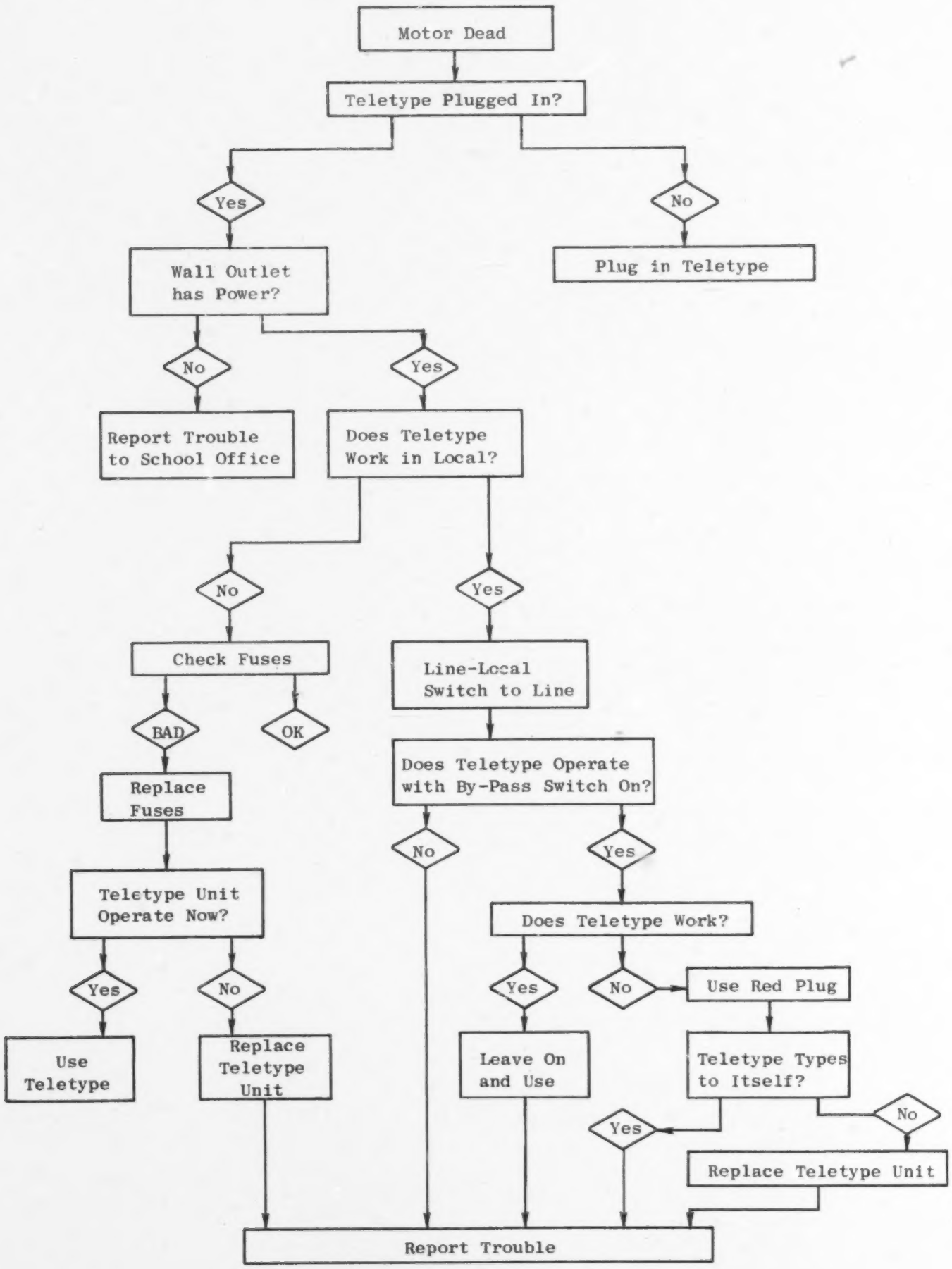

Fig. 14. Test for teletype motor. (Flow chart for check list on page 11.)

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